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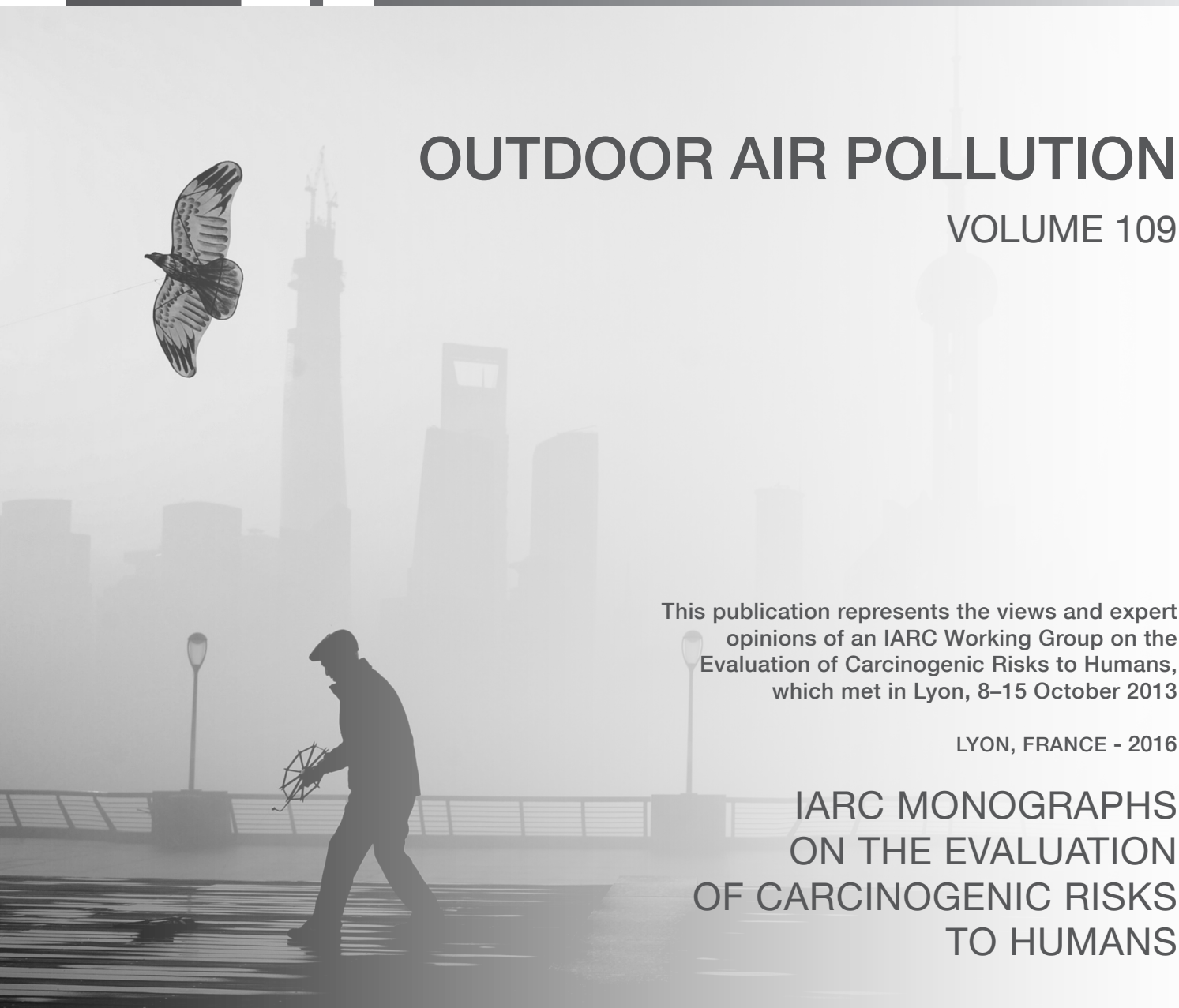

OUTDOOR AIR POLLUTION

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SUPPLEMENTAL TABLES SECTION 4

Supplemental Table S1 Summary of studies that used plant assays to assess the ability of outdoor air to induce genetic mutations

Geographical location	Sites examined	Test system/exposure	End-point examined	Results obtained	Reference
São Paulo metropolitan area, Brazil	3 sites in the vicinity of a solid waste incinerator in São Paulo, and a rural reference site	*Tradescantia* clone 4430, in situ exposures in pots for 5 months	*Tradescantia* stamen-hair mutation assay	Significant increase in mutation frequency relative to reference site. Negative correlation between mutation frequency and distance from incinerator source	Ferreira et al. (2000)
São Paulo metropolitan area, Brazil	Ibirapuera Park in the southern area of the city of São Paulo	*Tradescantia* clones 4430 and KU-20, in situ exposures in pots, biweekly sample collection for 1 yr	*Tradescantia* stamen-hair mutation assay	No significant increase in mutation frequency in 4430. Mutation frequency in KU-20 significantly increased in summer months and associated with elevated NO_2 and NO	Ferreira et al. (2007)
São Paulo metropolitan area, Brazil	Two urban sites in the city of São Paulo, and a rural reference site	*Tradescantia* 4430, in situ exposures in pots, monthly sample collection after initial 2-month exposure	*Tradescantia* stamen-hair mutation assay	Significant increase in mutation frequency at the high-traffic site only. Positive correlation between mutation frequency and suspended PM levels	Ferreira et al. (2003)
São Paulo metropolitan area, Brazil	High-traffic, urban site in São Paulo, and a rural reference site	*Tradescantia* clone KU-20, chamber exposures of inflorescences to outdoor air or filtered (0.8 μm porosity) outdoor air, daily sampling for 35 d	*Tradescantia* stamen-hair mutation assay	São Paulo outdoor air induced a significant increase in mutation frequency relative to reference site. Particle removal contributed to a reduction in mutation frequency, but frequency still elevated relative to reference site. Mutation frequency at São Paulo significantly correlated with PM_{10}	Guimarães et al. (2004)

Supplemental Table S1 (continued)

Geographical location	Sites examined	Test system/exposure	End-point examined	Results obtained	Reference
Variety of locations in the USA	19 locations that receive emissions from a wide range of urban/industrial sources, and 2 reference (control) locations	*Tradescantia* 4430, 10 d in situ exposures of cuttings in a climate-controlled mobile monitoring vehicle	*Tradescantia* stamen-hair mutation assay	Significant increases in mutation frequency at a range of urban and industrial sites. Highest mutation frequencies at site affected by facilities processing petroleum products	Schairer et al. (1982)
Toulouse metropolitan area, France	8 urban/ industrial locations, and a remote reference site	*Nicotiana tabacum* var. *Xanthi*, in situ exposures in pots for 1 month	Reverse mutation at 2 independent loci involved in chlorophyll parenchyma differentiation	Significant effect of treatment (i.e. site) on reversion rate. Highest reversion rate associated with industrial site. Lower reversion rate in 1997 significantly lower than in 1981, and decline corresponds with substantial decreases (> 2-fold) in atmospheric SO_2 and NO_2	Vergé et al. (2004)
Midwestern USA	15 sites in Ohio, Kentucky, Indiana, Illinois, and Colorado that cover a range of PM_{10} levels	Leaves and seeds of *Taraxacum officinale* Weber, *sensu lato* collected from field sites (in situ)	Mutation rates at minisatellite loci (parent–offspring transmission)	No relationship between minisatellite mutation rate and PM_{10} levels	Rogstad et al. (2003)
Sofia region, Bulgaria	A residential site (low PM_{10}) and an urban site (high PM_{10}) in Sofia	*Chlamydomonas reinhardtii* (WT 137C) exposed to samples diluted in DMSO (details not provided)	Visible size, morphology, and pigmentation mutants	Weak mutagenic effect (i.e. induced mutation frequency and mutagenic index) for summer samples from both urban sites. No effect for autumn samples	Dimitrova et al. (2007, 2009)
Moravia region, Czech Republic	3 samples from 2 industrial locations at Brno and Valašské Meziříčí. DCM extract of material collected on PUF plugs with high-volume sampler	Gametic mutations in *Arabidopsis thaliana*, seed exposure for 24 h	Frequency of siliques bearing mutant embryos	Significant increase relative to control for 2 of 3 samples. Highest mutation frequency associated with site near coal-tar conversion facility	Chroust et al. (1997)

d, day or days; DCM, dichloromethane; DMSO, dimethyl sulfoxide; h, hour or hours; NO, nitrogen oxide; NO_2, nitrogen dioxide; PM, particulate matter; PM_{10}, particulate matter with particles of aerodynamic diameter < 10 μm; PUF, polyurethane foam; SO_2, sulfur dioxide; yr, year or years.

Supplemental Table S2 Summary of studies that used *Saccharomyces cerevisiae* in vitro assays to assess the ability of outdoor air to induce genetic mutations

Geographical location	Test article	Assay/exposure system	End-point(s) examined	Results	Reference
Po Valley, Italy (1990)	Airborne PM from residential/commercial locations in Parma, collected on GFFs with low-volume sampler. Tl Soxhlet extraction	Diploid D7 strain of *S. cerevisiae*, 2 h exposure to extract in DMSO, with and without endogenous metabolic activation (i.e. elevated P450 in log-phase cells)	Mitotic gene conversion of *trp5* locus, reversion of *ilv1–92* mutants, mitochondrial DNA mutations ("petite" colonies)	6 of 9 24 h samples collected over a 9-month period induced significant dose-related increases in *trp5* conversions without endogenous activation. 5 of 9 samples tested with activation elicited significant responses. Only one sample with endogenous activation induced a significant dose-related increase in *ilv1* reversion. Increase in petite colonies for spring and summer samples	Poli et al. (1992)
Po Valley, Italy (1990–1994)	Airborne PM from residential/commercial locations in Parma, collected on GFFs with low-volume sampler. Tl or Ac Soxhlet extraction	Diploid D7 strain of *S. cerevisiae*, 2 h exposure to extract in DMSO, with and without endogenous metabolic activation (i.e. elevated P450 in log-phase cells)	Mitotic gene conversion of *trp5* locus, reversion of *ilv1–92* mutants, mitochondrial DNA mutations ("petite" colonies)	48 monthly samples analysed. Several samples induced increases in point mutations and gene conversions both with and without endogenous activation. High variability across year and season. No evidence of temporal decline in outdoor air mutagenicity between 1990 and 1994. Several samples induced > 10-fold increase over control. Stronger response for Tl extracts. Several Tl extracts induced increases in mitochondrial DNA mutations	Rossi et al. (1995)
Po Valley, Italy (1991–1998)	Airborne PM from residential/commercial locations in Parma, collected on GFFs with low-volume sampler. Tl Soxhlet extraction	Diploid D7 strain of *S. cerevisiae*, 2 h exposure to extract in DMSO, with and without endogenous metabolic activation (i.e. elevated P450 in log-phase cells)	Mitotic gene conversion of *trp5* locus, reversion of *ilv1–92* mutants, mitochondrial DNA mutations ("petite" colonies)	96 pooled monthly samples analysed. With endogenous activation, several samples induced significant dose-related (equiv m^3/mL) increases in point mutations and gene conversions. No evidence of temporal decline in outdoor air mutagenicity between 1991 and 1998	Poli et al. (1999)
Po Valley, Italy (1996, 1997)	Airborne PM from residential/commercial locations in Parma, collected on GFFs with low-volume sampler. Tl or Ac Soxhlet extraction	Diploid D7 strain of *S. cerevisiae*, 2 h exposure to extract in DMSO, with and without endogenous metabolic activation (i.e. elevated P450 in log-phase cells)	Mitotic gene conversion of *trp5* locus, reversion of *ilv1–92* mutants	Significant induction of gene conversion and point mutations, and potency values (rev/equiv m^3) revealed significantly greater activity associated with Tl extract. Size fractionation showed that $PM_{2.5}$ is frequently more mutagenic (per µg of PM) than PM_{10} or TSP	Buschini et al. (2001)

Supplemental Table S2 (continued)

Geographical location	Test article	Assay/exposure system	End-point(s) examined	Results	Reference
Pisa, Italy (1993–1994)	Airborne PM from 2 locations, collected on cellulose nitrate filters with low-volume sampler. Sequential extraction with DCM and MeOH	Diploid D7 strain of *S. cerevisiae*, 4 h exposure to extract in DMSO, with and without PB/5,6-BF-induced murine hepatic S9	Mitotic gene conversion of *trp5* locus, reversion of *ilv1–92* mutants	Significant induction of gene conversion and point mutations without S9 (events/m^3) for high-traffic site only	Bronzetti et al. (1997)
Warsaw, Poland (1997–1998)	Airborne PM from an urban location, 12 composite monthly samples, collected on GFFs. DCM Soxhlet extraction	Haploid *S. cerevisiae* XV185–^{14}C, 24 h exposure to extract in DMSO	Reversion of *trp5–48*, *arg4–17*, *lys1–1*, *ade2–1*, *his1–7*, and *hom3–10* mutants	No significant increase in reversion relative to control (i.e. ratio of mutation frequency of exposed to solvent control < 2.0)	Jadczyk & Kucharczyk (2000)

Ac, acetone; 5,6-BF, 5,6-benzoflavone; DCM, dichloromethane; DMSO, dimethyl sulfoxide; equiv, equivalent; GFFs, glass-fibre filters; h, hour or hours; MeOH, methanol; PB, phenobarbital; PM, particulate matter; PM_{10}, particulate matter with particles of aerodynamic diameter < 10 μm; $PM_{2.5}$, particulate matter with particles of aerodynamic diameter < 2.5 μm; Tl, toluene; TSP, total suspended particles.

Supplemental Table S3 Seasonal trends in the geometric mean *Salmonella* TA98 mutagenic potency of extracts of outdoor air particulate matter

Season	Number of samples	Mutagenic potency (revenants/m³)			
		Without S9		With S9	
		Geometric mean*	Standard error of the mean	Geometric mean*	Standard error of the mean
Winter	1163	13.5[a]	1.0	13.4[a]	1.1
Autumn	288	17.3[a]	1.1	13.3[a]	1.1
Spring	210	9.9[b]	1.1	9.4[b]	1.1
Summer	282	5.4[c]	1.1	5.2[c]	1.1

* Mean values accompanied by a different letter are significantly different at $P < 0.01$.

Supplemental Table S4 Geometric mean *Salmonella* TA98 mutagenic potency of organic extracts of outdoor air particulate matter collected from urban, industrial, residential, and rural locations

Site type	Number of samples	Mutagenic potency (revenants/m³)			
		Without S9		With S9	
		Geometric mean*	Standard error of the mean	Geometric mean*	Standard error of the mean
Urban	615	17.3[a]	1.1	12.3[a]	1.0
Industrial	323	13.5[a]	1.0	10.0[a]	1.1
Residential	259	7.8[b]	1.1	6.4[b]	1.1
Rural	441	5.0[c]	1.3	6.0[b]	1.1

* Mean values accompanied by a different letter are significantly different at $P < 0.01$.

Supplemental Table S5 Summary of studies that used bacterial mutagenicity assays (e.g. Ames assay) to assess the ability of outdoor air to induce genetic mutations – North America

Geographical location	Test article	*Salmonella* strains[a], assay version	Results	Reference
Washington, DC, USA	Time-integrated (baghouse) urban PM collected in 1976 and 1977 (SRM 1649). DCM sonication extraction	TA98, TA100, standard plate incorporation and pre-incubation assays, with and without S9 from Wistar rat liver, Aroclor 1254 induction, or PB/5,6-BF induction	S9 source had no effect on TA100 mutagenicity (per µg of EOM). Stronger response with TA98, and TA98 mutagenicity increased with Aroclor-induced S9. Similar responses for plate incorporation and pre-incubation versions	Tokiwa et al. (1992)
Washington, DC, USA	Time-integrated (baghouse) urban PM collected in 1976 and 1977 (SRM 1649). Sequential Soxhlet extraction with DCM and MeOH, fractionation on silica, acid–base–neutral fractionation	TA98, TA100, standard plate incorporation assay, with and without rat liver S9	Higher potency (per µg of EOM or per µg of PM) without S9, and DCM extracts more potent compared with MeOH extracts. Highest activity (92% of direct acting) in polar (MeOH) eluate. Acid–base–neutral fractionation revealed strong activity in acid fraction	Nishioka et al. (1985)
Washington, DC, USA	Time-integrated (baghouse) urban PM collected in 1976 and 1977 (SRM 1649). DCM sonication extraction, separate, sequential extraction with Hx, Hx:DEE (9:1), Hx:DEE (1:1), MeOH	TA98, TA100, standard plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Stronger response on TA98 (per µL of extract), and clear increase in potency without S9. Clear increase in potency with increasing solvent polarity. PAHs, nitro-PAHs, and heterocyclic compounds detected in DCM extract. Polar extract contained some known mutagens, but compounds that contribute to activity without S9 largely unknown	Savard et al. (1992)
Washington, DC, USA	Time-integrated (baghouse) urban PM collected in 1976 and 1977 (SRM 1649). Two sequential DCM extractions followed by Ac Soxhlet extraction	TA98, TA100, standard plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Addition of S9 increased activity of DCM extract (per mg of PM) on TA98 and TA100. Substantial fraction of total mutagenic activity associated with Ac extract; 11–13% with S9, 20–21% without S9	Nielsen (1992)
Washington, DC, USA	Time-integrated (baghouse) urban PM collected in 1976 and 1977 (SRM 1649). DCM sonication extraction	TA98, TA100, microsuspension assay, with and without Aroclor 1254-induced rat liver S9	Highest potency (per µg of EOM) on TA98 without S9. No significant effect of S9 for TA100. Microsuspension technique contributed to 3–9-fold increases in potency, relative to plate incorporation	Agurell & Stensman (1992)

Supplemental Table S5 (continued)

Geographical location	Test article	*Salmonella* strains[a], assay version	Results	Reference
Washington, DC, USA	Time-integrated (baghouse) urban PM collected in 1976 and 1977 (SRM 1649). DCM Soxhlet extraction	TA98, TA98NR, TA98/1,8-DNP_6, microsuspension assay, with and without Aroclor 1254-induced rat liver S9	Highest activity (per µg of extract or per µg of PM) on TA98 without S9. Significant reduction in potency on TA98/1,8-DNP_6, relative to TA98, without S9. Modest reduction on TA98NR	Bagley et al. (1992)
Washington, DC, USA	Time-integrated (baghouse) urban PM collected in 1976 and 1977 (SRM 1649). Sequential DCM, Ac Soxhlet extraction	TA98, TA98NR, TA98/1,8-DNP_6, standard plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Potency (per µg of EOM) on TA98 higher without S9, and Ac extracts more potent compared with DCM extracts. Significant reduction in potency without S9 on TA98NR and TA98/1,8-DNP_6, relative to TA98	Gundel et al. (1993)
Washington, DC, and Philadelphia, Pennsylvania, USA	Time-integrated (baghouse) urban PM collected in 1976 and 1977 (SRM 1648 and SRM 1649). Ac Soxhlet extraction	Plate incorporation assay with Ames II base-pair substitution strains TA7001, TA7002, TA70003, TA7004, TA7005, TA7006, without S9 activation	Mutagenic potency (per mg of PM) enhanced on TA7005 (CG to AT transversions), TA7004 (CG to TA transitions), TA7002 (TA to AT transversions), and TA70006 (CG to GC transversions)	Erdinger et al. (2004)
Elizabeth, New Jersey, USA (winter 1983)	Airborne PM from 10 suburban locations, collected on GFFs with high-volume sampler. Sequential CX, DCM, Ac Soxhlet extraction, fractionation by polarity	TA98, TA98NR, TA98/1,8-DNP_6, standard plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Potency (per µg of EOM) on TA98 higher without S9, and increase in potency on polar fraction. Significant reduction in potency without S9 on TA98NR and TA98/1,8-DNP_6, relative to TA98	Gundel et al. (1993)
New York City, USA (1977–1979)	Airborne PM collected on GFFs from cyclone sampler. CX, DCM, or Ac Soxhlet extraction	TA98, TA100, standard plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Mutagenic activity of the various extracts all elevated without S9; moderately polar fraction showed highest activity. Polar fraction generally showed higher potency (per m^3) in winter; non-polar or moderately polar fractions showed higher potency in autumn and winter. Estimated that half of activity per m^3 in winter from fuel oil combustion for residential heating. Maximum total potency on TA98 without S9 ~12 rev/m^3	Daisey et al. (1980)
Chicago, Illinois, USA (1975)	Airborne PM collected with high-volume sampler. Soxhlet extraction with BZ:Hx:IProp (7:1:2), TLC fractionation	TA1538, standard plate incorporation assay, with Aroclor 1254-induced rat liver S9	Higher activity (per mg of PM) with S9; no obvious seasonal trend. Higher mutagenicity associated with wind direction	Commoner et al. (1978)

Supplemental Table S5 (continued)

Geographical location	Test article	*Salmonella* strains[a], assay version	Results	Reference
Wayne County, Michigan, USA (1978)	Airborne PM collected on GFFs with high-volume sampler. BZ Soxhlet extraction	TA98, TA98NR, standard plate incorporation assay, without rat liver S9	Significant mutagenic activity (per µg of EOM), frequently elevated in residential areas downwind of urban/industrial areas. Potency (per µg of EOM) significantly reduced on NR-deficient strain. Some elevation in potency (per m^3) in the autumn. Maximum potency without S9 ~177 rev/m^3	Wang et al. (1980)
Detroit, Michigan, USA (1982)	Airborne PM from urban/industrial area, collected on quartz filters with high-volume sampler. DCM Soxhlet extraction, fractionation by TLC	TA98, TA98NR, TA98/1,8-DNP_6, standard plate incorporation assay, without rat liver S9	Mutagenic activity (per µg of EOM) predominantly in polar fractions. Significant positive association between mutagenicity and atmospheric SO_2, and variables that reflect vehicular emissions. Potency (per m^3) generally lower in summer. Maximum potency without S9 ~26 rev/m^3	Wolff et al. (1986)
West Virginia, USA (1984)	Outdoor PM collected on GFFs with high-volume sampler. Ac extraction	TA98 and TA98NR, standard plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Similar potency (per mg of PM) with and without S9	Krishna et al. (1986)
Southern California, USA (1993)	Airborne PM from central Los Angeles, Azusa, Rubidoux, Long Beach, and control site (San Nicolas Island). Collected on quartz-fibre filters with virtual impactor. DCM Soxhlet extraction	*Salmonella* TM677 forward mutation assay (*Xprt*), with and without Aroclor 1254-induced rat liver S9	Mutagenic potency (per m^3) significantly decreased with S9. Source apportionment revealed that diesel PM and natural gas combustion made the largest contribution to potency without S9; natural gas combustion made the largest contribution to potency with S9	Hannigan et al. (2005)
Southern California, USA (1982)	Airborne PM from Azusa and Long Beach, collected on quartz-fibre filters from cyclone separator. DCM Soxhlet extraction	*Salmonella* TM677 forward mutation assay (*Xprt*), with and without rat liver S9	Higher mutagenicity without S9; higher potency (per µg of EOM) for Long Beach. Mutagenic activity much higher than expected based on examined sources	Hannigan et al. (1994)
Southern California, USA (1993)	Airborne PM from 4 urban/industrial locations and 1 reference location, collected with virtual impactor or cyclone separator. DCM Soxhlet extraction	*Salmonella* TM677 forward mutation assay (*Xprt*), with and without Aroclor 1254-induced rat liver S9	Mutagenic potency (per m^3) of fine PM from urban sites showed pronounced seasonality; high in winter and low in summer; generally higher without S9. No seasonal differences in potency (per µg of EOM). Urban sites also more potent (per µg of EOM); 10-fold above reference location. Location downwind of urban area more potent with S9	Hannigan et al. (1996)

Supplemental Table S5 (continued)

Geographical location	Test article	*Salmonella* strains[a], assay version	Results	Reference
Southern California, USA (1976)	Airborne PM from 8 urban locations and 1 rural location, collected on GFFs with high-volume sampler. DCM:MeOH:BZ (1:1:1) sonication extraction	TA98, TA100, TA1535, TA1537, TA1538, standard plate incorporation assay, with and without rat liver S9	Highest mutagenicity on TA98 without S9. Mutagenic potency (per µg of EOM) similar across urban sites, with highest activity at Los Angeles. No response for rural site	Pitts et al. (1977)
Claremont, California, USA (1987)	Airborne PM collected on Teflon-impregnated GFFs with high-volume sampler. DCM Soxhlet extraction, detailed fractionation	TA98, microsuspension assay, without S9 activation	High mutagenic activity in fractions containing nitro-PAHs. PAH reaction products such as nitro-PAH lactones suspected as major contributors to mutagenicity. Maximum potency without S9 ~160 rev/m^3	Arey et al. (1992)
Claremont and Torrance, California, USA (1986)	Airborne PM collected on Teflon-impregnated GFFs with high-volume sampler. DCM Soxhlet extraction	TA98, standard plate incorporation assay, without S9 activation	Mutagenic potency (per m^3) frequently elevated in winter compared with autumn. Maximum potency ~120 rev/m^3. Results indicate that atmospheric formation of nitroarenes is an important determinant of PM mutagenicity	Arey et al. (1988)
El Monte, California, USA (1980)	Airborne PM (< 20 µm) collected on GFFs, Teflon, quartz, or Teflon-impregnated filters. Tl:DCM:MeOH sonication extraction	TA98, standard plate incorporation assay, with and without rat liver S9	Mutagenic potency (per µg of EOM or m^3) similar with and without S9; no difference for different filter media. Maximum potency without S9 ~35 rev/m^3; with S9 ~33 rev/m^3	Fitz et al. (1984)
Redlands, California, USA (1984)	SVOCs collected on PUF plugs. DCM Soxhlet extraction, HPLC fractionation	TA98, microsuspension assay, without rat liver S9	Higher mutagenic activity (per m^3) at night. Nitro- and methylnitro-naphthalenes accounted for 18–32% of SVOCs mutagenic activity. Maximum potency without S9 ~31 rev/m^3	Gupta et al. (1996)
West Virginia, USA (1982)	Airborne PM collected on GFFs with high-volume sampler. Shaker extraction with Ac, BZ, CX, MeOH, DCM, or BZ:CX:MeOH (1:1:1)	TA98, TA100, standard plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Evaluation of various extraction solvents; highest mutagenic activity associated with DCM extract. Highest activity on TA100 with S9. Additional analyses showed that sonication is effective for extraction and possibly superior to Soxhlet	Krishna et al. (1983)
West Virginia, USA (1982)	Airborne PM collected on GFFs with high-volume sampler. Ac extraction by sonication, shaker, or Soxhlet	TA98, TA100, standard plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Sonication is effective for extraction, and some indication that it is superior compared with Soxhlet and shaker	Krishna et al. (1983)

Supplemental Table S5 (continued)

Geographical location	Test article	*Salmonella* strains[a], assay version	Results	Reference
West Virginia, USA (1982)	Airborne PM collected on GFFs with high-volume sampler. Ac extraction	TA98, standard plate incorporation assay, without metabolic activation	Significant positive response on both TA100 and TA98. Potency (per mg of PM) higher on TA98	Krishna et al. (1984)
West Virginia, USA (1980)	Airborne PM from 5 sites near Morgantown, collected with cascade impactor. Sequential shaker extraction with DCM and EA:MeOH (1:1), acid–base–neutral fractionation	TA98, TA100, SV50 (Ara test), standard plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Mutagenic potency (per mg of PM) higher without S9 in summer, with S9 in autumn and winter. High activity in acidic and PAH fractions. Drop in potency (per m^3) after rain or snow. Maximum potency on TA98 with S9 ~46 rev/m^3; without S9 ~85 rev/m^3	Whong et al. (1981)
West Virginia, USA (1982)	Airborne PM from Morgantown, collected on GFFs with high-volume sampler. DCM shaker extraction	TA98, standard plate incorporation assay, without metabolic activation	52% of mutagenic activity associated with PM < 2 µm. Mutagenic potency of PM < 1.1 µm ~25 rev/m^3	Sorenson et al. (1982)
Lexington, Kentucky, USA (1980)	Airborne PM before and during forest fires, collected on GFFs with high-volume sampler. BZ and Ac sonication extraction	TA98, TA100, standard plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Mutagenic potency (per m^3) on TA98 elevated with S9 for "smoky" conditions; higher without S9 for "non-smoky" conditions. Potency (per µg of EOM) similar for different sample types; "smoky" far higher per mg of PM or per m^3. Potency on TA98 for "smoky" conditions with S9 ~45 rev/m^3; without S9 ~27 rev/m^3. For "non-smoky" conditions, potency on TA98 with S9 ~1 rev/m^3; without S9 ~2 rev/m^3	Viau et al. (1982)
Houston, Texas, USA (1977–1978)	Airborne PM collected on GFFs with high-volume sampler. Combined Ac, CX, MeOH, Chl extraction	TA1535, TA1537, TA98, TA100, plate incorporation assay, with and without rat liver S9	Mutagenic activity highest on TA98 with S9. Positive correlation between mutagenic activity (per m^3) and lung cancer incidence. Maximum mutagenic potency on TA98 ~6 rev/m^3	Walker et al. (1982)
Houston, Texas, USA	TSP collected on GFFs with high-volume sampler. Soxhlet extraction with CX or BZ:MeOH:DCM (1:1:1)	TA1535, TA1537, TA1538, TA98, TA100, spot test, TA98 and TA100 plate incorporation assay, with and without rat liver S9	Elevated mutagenic activity (per mg of TSP) without S9; solvent mixture more effective for extracting mutagens	Preidecker (1980a)

Supplemental Table S5 (continued)

Geographical location	Test article	*Salmonella* strains[a], assay version	Results	Reference
Houston, Texas, USA	Airborne TSP or size-fractionated PM collected with high-volume sampler or cascade impactor. PM collected on GFFs. BZ:MeOH:DCM (1:1:1) Soxhlet extraction	TA98, TA100, TA1538, TA1978 (TA1538 *uvrB*+), standard plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Mutagenic potency (per mg of TSP) highest at sites downtown or south/south-west of downtown. Potency highest without S9 for both TA98 and TA100. Cascade impactor samples showed dramatically increased potency (per m^3) for finest material (< 1 µm). No significant response on TA1978, relative to strong response on TA1538. Maximum mutagenic potency on TA98 without S9 ~3.5 rev/m^3	Preidecker (1980b)
Contra Costa County, California, USA (1981–1982)	Airborne PM from 4 urban/residential sites, collected on GFFs with high-volume sampler. BZ extraction	TA98, standard plate incorporation assay, with and without Aroclor 1254-induced liver S9	Mutagenic potency (per m^3 or per µg of EOM) higher in summer, and highest potency (per m^3) at sites near heavy traffic and oil-burning electric power facility. All samples more potent (per m^3) with S9. Significant correlations between potency (per m^3) and lead in fine PM (< 2.5 µm) as well as atmospheric NO_2. Maximum mutagenic potency on TA98 without S9 ~12 rev/m^3; with S9 ~30 rev/m^3	Flessel et al. (1985)
Contra Costa County, California, USA (1978–1979)	Airborne PM from 15 urban/residential sites, collected on GFFs with high-volume sampler. BZ extraction	TA1537, TA1537, TA1538, TA98, TA100, standard plate incorporation assay, with and without rat liver S9	All samples mutagenic in at least one strain; highest activity on TA98. Mutagenic potency (per m^3) higher with S9 and generally higher in winter. Elevated potency at more-urban settings with higher PAH levels. Maximum mutagenic potency on TA98 without S9 ~6 rev/m^3; with S9 ~25 rev/m^3	Flessel et al. (1980)
Los Angeles, California, USA (1983)	PM_{10} from 2 sites near San Diego Freeway, collected on Teflon-coated filters with high-volume sampler. DCM Soxhlet extraction	TA98, TA98NR, standard plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Diurnal analyses showed rapid changes (over several hours) in mutagenic potency (per m^3). Similar potencies with and without S9, and clear reduction on TA98NR. Potency of samples downwind of freeway showed elevated potency and correspondence with atmospheric lead, CO, and NO_x. Maximum potency on TA98 with S9 ~140 rev/m^3; without S9 ~140 rev/m^3	Pitts et al. (1985)

Supplemental Table S5 (continued)

Geographical location	Test article	*Salmonella* strains[a], assay version	Results	Reference
California, USA (1982)	Coarse (< 15 μm) and fine (< 2.5 μm) PM from 3 locations, collected on GFFs with high-volume sampler. MeOH:DCM:Tl (1:1:1) sonication extraction	TA98, TA98NR, standard plate incorporation and microsuspension assays, with and without rat liver S9	10-fold increase in mutagenic potency on microsuspension assay, relative to plate incorporation. Mutagenic potency without S9 (per m^3) lower on TA98NR relative to TA98. Elevated potency without S9 and activity associated with $PM_{2.5}$ only. Maximum potency on TA98 (microsuspension) with S9 ~1100 rev/m^3; without S9 ~450 rev/m^3. Potency correlated with lead levels	Kado et al. (1986)
Buffalo, New York (1962) and Berkeley, California, USA	Airborne PM, collected on GFFs. Ac Soxhlet extraction	TA1535, TA1537, TA98, and TA100, standard plate incorporation assay, with and without rat liver S9 (induced and uninduced)	Archived Buffalo PM samples showed enhanced potency (per μg of EOM) with S9 and maximum response with Aroclor-induced S9. Berkeley sample potency (per μg of EOM) higher without S9. Berkeley samples more potent than Buffalo samples without S9, and less potent than or equivalent to Buffalo samples with S9	Talcott & Wei (1977)
Boise, Idaho, USA (1986–1987)	$PM_{2.5}$ from 7 sites during winter, collected on GFFs with high-volume sampler. DCM sonication extraction	TA98, TA100, plate incorporation and microsuspension assays, with and without Aroclor 1254-induced rat liver S9	Mutagenic potency (per m^3) higher without S9 for microsuspension only. Highest mean potency > 100 rev/m^3. Microsuspension potency ~3-fold higher than plate incorporation potency. Potency at primary sites significantly higher than at reference (background) site. Background activity accounted for 7–19% of activity at primary sites. Maximum potency on TA98 (microsuspension) with S9 ~147 rev/m^3; without S9 ~312 rev/m^3	Claxton et al. (2001)
Boise, Idaho, USA (1986–1987)	Composite $PM_{2.5}$ sample, collected on GFFs with high-volume sampler. DCM sonication extraction, fractionation on anion exchange resin	TA98, TA1538, TA100, plate incorporation and microsuspension assays, with and without Aroclor 1254-induced rat liver S9	Composite sample prepared to maximize contributions from mobile-source emissions. Highest activity (TA98 with S9 per μg of EOM) in base–neutral fraction. Majority of TA98 reversion mutations similar to that observed for B[*a*]P. GC to TA transversion mutations in TA100 predominated for both PM extract and B[*a*]P	DeMarini et al. (1994)
Newark, New Jersey, USA (1988)	Airborne PM from residential/industrial location, collected on GFFs with high-volume sampler. Sequential Soxhlet extraction with DCM and Ac, detailed fractionation	TA98, TA98NR, TA98/1,8-DNP_6, TA100, plate incorporation and microsuspension assays, with and without Aroclor 1254-induced rat liver S9	Analyses of fractions from seasonal composites indicated similar profiles of mutagenic activity across seasons; shift to molar polar compounds in summer. Polar neutral aromatics important contributor to activity of all samples; highly polar acidic fractions showed strong activity on TA100	Greenberg et al. (1993)

Supplemental Table S5 (continued)

Geographical location	Test article	*Salmonella* strains[a], assay version	Results	Reference
Rutland, Vermont, USA (1987–1988)	TSP and PM_{10} from a site near a municipal incinerator, collected on GFFs with high-volume sampler. DCM sonication extraction	TA98, plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Similar mutagenic potency (per m^3) with and without S9. Maximum potency on TA98 without S9 ~35 rev/m^3; with S9 ~25 rev/m^3. No detection of mutagens that could be linked to incinerator activities	Watts et al. (1989)
Allegheny County, Pennsylvania, USA	Airborne PM from 4 locations, collected with cascade impactor. Ac Soxhlet extraction	TA98, TA100, TA1538, plate incorporation assay, with and without rat liver S9	Mutagenic potency (per µg of EOM) higher with S9 and elevated on TA98 compared with other strains. Highest mutagenicity associated with finest size fractions (0.5–1.5 µm)	Sideropoulos & Specht (1994)
Ann Arbor, Michigan, USA (1991)	Airborne PM, collected on GFFs with cascade impactor. Sequential Soxhlet extraction with DCM	TA98, TA100, TA102, plate incorporation and plate incorporation assay, without S9 activation	Strong responses on TA98 and TA100; lower for TA102. Maximum potency on TA98 without S9 ~4 rev/m^3; on TA100 without S9 ~9 rev/m^3	Hoyer et al. (1992)
New Mexico and North Carolina, USA (1984–1985)	$PM_{2.5}$ samples from Albuquerque (New Mexico) and Raleigh (North Carolina), collected with cascade impactor. DCM sonication extraction	TA98, plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Mutagenic potency on TA98 with ~20–30 rev/m^3. Contributions from wood smoke emissions to activity per unit of EOM greater than mobile-source emissions. Mobile sources made a much larger contribution to activity per m^3	Stevens et al. (1990)
Durham, North Carolina, USA (1978–1979)	Airborne PM, collected with cascade impactor. Ac Soxhlet extraction	TA98, plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Mutagenic potency (per m^3) almost always higher without S9; highest activity for PM < 2 µm. Maximum potency without S9 ~10 rev/m^3; with S9 ~6 rev/m^3	Talcott & Harger (1980, 1981)
Durham, North Carolina, USA (1989–1990)	PM_{10}, collected on several types of media with high-volume sampler. DCM sonication extraction	TA98, plate incorporation assay, with and without rat liver S9	Mutagenic potency (per m^3) of most samples elevated with S9; Teflon-impregnated GFFs yielded highest activity. Maximum potency with S9 ~50 rev/m^3	Watts et al. (1992)
Camden, New Jersey, USA (1983)	Airborne PM collected on GFFs with cascade impactor. Sequential Soxhlet extraction with CX, DCM, and Ac	TA98, TA100, standard plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Potency (per µg of EOM) of Ac extracts higher without S9. Potency of CX extracts slightly higher with S9. Ac extracts far more potent on TA98 than on TA100	Miguel et al. (1990)

Supplemental Table S5 (continued)

Geographical location	Test article	*Salmonella* strains[a], assay version	Results	Reference
Hamilton, Canada (1990–1991)	PM_{10} from 2 monitoring stations, collected on GFFs with high-volume sampler. Sequential Soxhlet extraction with DCM and MeOH, detailed fractionation	YG1021, standard plate incorporation assay, without S9 activation	Mutagenic potency (per m^3) of non-polar PAC fractions without S9 ranged from 1 rev/m^3 to 134 rev/m^3. Highest mutagenic activity associated with winds from east (e.g. urban Toronto), low wind velocities, high SO_2, and high NO_2	Morris et al. (1995)
Hamilton and Burlington, Canada (1990–1991)	Airborne PM collected on Teflon-coated GFFs with high-volume sampler. Sequential DCM, Ac extraction, extensive fractionation	YG1021, YG1024, YG1026, YG1029, TA98, TA100, standard plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Mutagenic potency (per m^3) of non-polar fraction without S9 dramatically increased on both YG1021 and YG1024 compared with TA98. Potency of non-polar fraction increased with S9 on all strains except YG1024. Relatively small fraction of activity contained in polar fraction (i.e. 12–33%). Maximum potency on TA98 without S9 ~4 rev/m^3; with S9 ~12 rev/m^3. Several potent PAHs and nitro-PAHs identified in non-polar fraction	Legzdins et al. (1995)
Hamilton, Canada (1975–1976)	Seasonal composites of airborne PM. BZ Soxhlet extraction, fractionation by TLC	TA1537, TA1538, TA1535, TA98, TA100, standard plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Mutagenic potency (per µg of EOM) greater on TA98, compared with TA100; similar results with and without S9	Salamone et al. (1979)
Mexico City, Mexico (1991)	Airborne TSP and PM_{10}, collected on GFFs with high-volume sampler. MeOH Soxhlet extraction	TA98, standard plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Increased mutagenic activity with S9, and PM_{10} extracts more mutagenic relative to TSP	Delgado-Rodríguez et al. (1999)
Mexico City, Mexico (1998)	PM_{10} from an urban site, collected on GFFs with high-volume sampler. DCM sonication extraction, fractionation on silica	TA98, YG1021, plate incorporation assay, with and without PB/5,6-BF-induced rat liver S9	Highest mutagenic activity in moderately polar fraction (PAHs and nitro-PAHs) and polar fraction. Positive correlation between activity without S9 and nitro-PAH concentrations. Positive correlation between activity with S9 and PAH concentrations. Maximum potency (per µg of EOM) on YG1021 associated with moderately polar fraction	Villalobos-Pietrini et al. (2007)
Mexico City, Mexico (1992)	PM_{10} from an urban site, collected on GFFs with high-volume sampler. DCM sonication extraction	TA98, plate incorporation assay, with and without rat liver S9	Mutagenic potency (per m^3) without S9 similar, or elevated, relative to with S9. Potency without S9 correlated with PM levels. Potency with S9 correlated with atmospheric NO_x and CO. Maximum potency on TA98 without S9 ~18 rev/m^3; with S9 ~20 rev/m^3	Villalobos-Pietrini et al. (1999)

Supplemental Table S5 (continued)

Geographical location	Test article	*Salmonella* strains[a], assay version	Results	Reference
Mexico City, Mexico (1989–1990)	PM_{10} and TSP from 5 locations, collected on GFFs with high-volume sampler. MeOH Soxhlet extraction	TA98, TA100, plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Mutagenic potency (per m^3) generally higher for PM_{10} compared with TSP; response significantly increased with S9	Villalobos-Pietrini et al. (1995)
Mexico City, Mexico (1998)	PM_{10} from south-western Mexico City, collected on GFFs with high-volume sampler. Sonication extraction with DCM	TA98, YG1021, plate incorporation assay, with and without rat liver S9	Mutagenic potency (per m^3) higher with S9 in summer; opposite for colder months. Highest potency during a dry period with many fires. Significant increases on YG1021 relative to TA98 only for colder months with ground-based inversions. Some positive associations between mutagenic activity and atmospheric levels of CO, NO_2, and SO_2; negative association with rainfall. Maximum potency on TA98 without S9 ~25 rev/m^3; with S9 ~52 rev/m^3	Villalobos-Pietrini et al. (2006)
Mexico City, Mexico (1990)	Airborne PM from 2 urban locations, collected on GFFs with high-volume sampler. DCM extraction of shredded filter	TA1538, TA98, YG1024, YG1021, TA98NR, plate incorporation assay, without rat liver S9	Mutagenic potency (per m^3) increased on both YG1021 and YG1024, and reduced on TA98NR, relative to TA98. Maximum potency on TA98 without S9 ~21 rev/m^3	Espinosa-Aguirre et al. (1993)
Mexico City, Mexico (1993)	PM_{10} and TSP from a residential area, collected on GFFs. Sequential Soxhlet extraction with CX, DCM, and Ac	TA98, plate incorporation assay, with and without rat liver S9	Mutagenic potency (per m^3) highest for Ac extract and frequently higher with S9. TSP extracts frequently more potent than PM_{10} extracts. Maximum potency on TA98 without S9 ~4.7 rev/m^3; with S9 ~4.2 rev/m^3	Amador-Muñoz et al. (2001)

[a] YG1021: TA98 with plasmid pYG216, NR-overproducing strain; YG1024: TA98 with plasmid pYG219, OAT-overproducing strain; YG1041: TA98 with plasmid pYG233, NR- and OAT-overproducing strain; YG1026: TA100 with plasmid pYG216, NR-overproducing strain; YG1029: TA100 with plasmid pYG219, OAT-overproducing strain; YG1042: TA100 with plasmid pYG233, NR- and OAT-overproducing strain.

Ac, acetone; 5,6-BF, 5,6-benzoflavone; B[*a*]P, benzo[*a*]pyrene; BZ, benzene; Chl, chlorophyll; CO, carbon monoxide; CX, cyclohexane; DCM, dichloromethane; DEE, diethyl ether; EA, ethyl acetate; EOM, extractable organic matter; GFFs, glass-fibre filters; HPLC, high-performance liquid chromatography; Hx, hexane; MeOH, methanol; NO_2, nitrogen dioxide; NO_x, nitrogen oxides; NR, nitroreductase; OAT, *O*-acetyltransferase; PACs, polycyclic aromatic compounds; PAHs, polycyclic aromatic hydrocarbons; PB, phenobarbital; PM, particulate matter; PM_{10}, particulate matter with particles of aerodynamic diameter < 10 μm; $PM_{2.5}$, particulate matter with particles of aerodynamic diameter < 2.5 μm; PUF, polyurethane foam; rev, revertants; SO_2, sulfur dioxide; SRM, standard reference mixture; SVOCs, semivolatile organic compounds; Tl, toluene; TLC, thin-layer chromatography; TSP, total suspended particles.

Supplemental Table S6 Summary of studies that used bacterial mutagenicity assays (e.g. Ames assay) to assess the ability of outdoor air to induce genetic mutations – South America

Geographical location	Test article	*Salmonella* strains[a]/assay version	Results	Reference
Rio de Janeiro, Brazil (1984)	Airborne PM collected on GFFs with cascade impactor. Sequential Soxhlet extraction with CX, DCM, and Ac	TA98, TA100, standard plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	For Rio de Janeiro, potency higher (per m^3 or per µg of EOM) without S9 on TA98; higher with S9 on TA100. Some indication of increased potency during the day. DCM extract potency generally exceeds Ac and CX extract potency. CX potency (per µg of EOM) similar across sites. Maximum potency on TA98 without S9 ~11.8 rev/m^3; with S9 ~8.5 rev/m^3	Miguel et al. (1990)
Rio Grande do Sul state, Brazil (2004–2005)	Airborne PM from 2 sites, collected on GFFs with high-volume sampler. DCM sonication extraction	TA98, TA100, YG1021, YG1024, microsuspension assay, with and without Aroclor 1254-induced rat liver S9	Elevated mutagenic potency (per m^3) at urban/industrial site, relative to non-industrial reference. PAH concentrations at urban/industrial site ~25-fold higher than at non-industrial site. Potency increased with S9. Potency for urban/industrial sample (per µg of PM) elevated on both NR- and OAT-enhanced strains. Maximum potency on TA98 without S9 ~19 rev/m^3; with S9 ~32 rev/m^3	Pereira et al. (2013)
Rio Grande do Sul state, Brazil (2004–2005)	TSP from an urban/industrial site and a rural site, collected on GFFs with high-volume sampler. DCM sonication extraction	TA98, TA100, YG1021, YG1024, microsuspension assay, with and without Aroclor 1254-induced rat liver S9	Mutagenic potency (per µg of EOM) increased on YG1021 and YG1024, relative to TA98; generally highest on YG1024. Potency (per m^3) substantially higher for urban/industrial site. Maximum potency on TA98 without S9 ~3 rev/m^3; with S9 ~4 rev/m^3	Pereira et al. (2010)
Rio Grande do Sul state, Brazil (2009–2010)	TSP and $PM_{2.5}$ from 2 urban/industrial sites, collected on GFFs and Teflon membrane filters with high-volume sampler. Sequential sonication extraction with DCM and water	TA98, YG1021, YG1024, microsuspension assay, with and without rat liver S9	Potency (per µg of PM) of all DCM extracts higher for $PM_{2.5}$, relative to TSP. Water extracts all negative for mutagenic activity. Enhanced activity on metabolically enhanced strains, particularly NR-enhanced strain YG1021. High temporal variability in effect of S9 on TA98 mutagenic potency (per m^3). Maximum potency on TA98 without S9 ~2.5 rev/m^3; with S9 ~2.3 rev/m^3	Lemos et al. (2012)

Supplemental Table S6 (continued)

Geographical location	Test article	*Salmonella* strains[a]/assay version	Results	Reference
São Paulo, Brazil (1994)	Airborne PM_{10} from a residential/commercial site in São Paulo city, collected on Teflon-coated GFFs with high-volume sampler. Sequential sonication extraction with DCM and Ac, fractionation on bonded-phase column	TA98, YG1021, YG1024, microsuspension assay, with and without Aroclor 1254-induced rat liver S9	Mutagenic potency (per m^3) of crude extract increased with S9. Moderately polar fractions of DCM extract increased with S9. Polar fractions higher without S9. Moderately polar and polar fractions of Ac extract more mutagenic without S9. Maximum potency on TA98 without S9 ~150 rev/m^3; with S9 ~165 rev/m^3. The most mutagenic DCM extract fractions contained ketones, aldehydes, and quinolines. PAH concentration ratios indicate mobile-source contributions	De Martinis et al. (1999, 2002)
São Paulo, Brazil	Airborne PM from 2 sites in São Paulo city, collected on GFFs with high-volume sampler. DCM sonication extraction	TA98, pre-incubation assay, with and without Aroclor 1254-induced rat liver S9	Mutagenic potency (per µg of EOM) dramatically reduced with S9	Umbuzeiro et al. (2010)
São Paulo, Brazil (2004)	Airborne PM from 2 sites in São Paulo city, collected on quartz filters with high-volume sampler. DCM Soxhlet extraction, fractionation on silica	TA98, YG1041, microsuspension assay, with and without Aroclor 1254-induced rat liver S9	Elevated potency (per µg of PM) on TA98 without S9 for nitro-PAH and oxy-aromatic fractions. Dramatic increases on YG1041, relative to TA98. Elevated potency for higher-traffic site	Umbuzeiro et al. (2008)
São Paulo state, Brazil (1990–1991)	Airborne PM from 3 urban/industrial locations, collected on GFFs or quartz filters with high-volume sampler. DCM Soxhlet extraction	TA98, TA100, TA98NR, plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Mutagenic potency (per m^3) highest on TA98, except for winter. Highest activity for heavy-traffic site. Pooled seasonal samples showed lower potency in winter; generally higher on TA98 without S9. Maximum potency on TA98 ~246 rev/m^3 without S9; ~120 rev/m^3 with S9. Reductions in potency on TA98NR and TA98/1,8-DNP_6, relative to TA98	Sato et al. (1995)
São Paulo state, Brazil (2002–2004)	PM_{10} from Araraquara, collected on Teflon-coated GFFs or quartz filters with high-volume sampler. DCM:MeOH (4:1) sonication extraction	YG1024, pre-incubation assay, with and without Aroclor 1254-induced rat liver S9	Mutagenic potency (per m^3) higher without S9 and elevated (5–10-fold) during sugar-cane harvest period (i.e. field burning) compared with non-harvest period	de Andrade et al. (2011)

Supplemental Table S6 (continued)

Geographical location	Test article	*Salmonella* strains[a]/assay version	Results	Reference
São Paulo state, Brazil (2003)	PM_{10} from Araraquara, Piracicaba, and São Paulo city, collected on GFFs with high-volume sampler. DCM Soxhlet extraction	TA98, TA100, YG1041, YG1042, microsuspension assay, with and without Aroclor 1254-induced rat liver S9	Mutagenic potency (per m^3) on TA98 higher without S9; highest in areas affected by cane-burning activities. Dramatic increase in potency on YG1041 without S9, relative to TA98. Maximum potency on TA98 ~320 rev/m^3 without S9; ~57 rev/m^3 with S9 (cane-burning area); ~450 rev/m^3 without S9; ~140 rev/m^3 with S9 (São Paulo City). Strong contributions from nitro-PAHs and oxy-aromatics	Umbuzeiro et al. (2008)
Santiago, Chile (1996)	PM_{10} and TSP from an urban, heavy-traffic site, collected on Teflon-coated filters and GFFs with high-volume sampler. DCM sonication extraction	TA98, plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Mutagenic potency varied during the year, reached up to 700 rev/m^3 during summer (without S9). Potency often elevated without S9. Maximum potency on TA98 with S9 ~620 rev/m^3. Potency of TSP elevated relative to PM_{10}. PAHs elevated during summer months	Adonis & Gil (2000)
Santiago, Chile (1990–1991)	Airborne PM from an urban, heavy-traffic site, collected on GFFs with high-volume sampler. DCM sonication extraction	TA98, TA98NR, TA98/1,8-DNP_6, plate incorporation assay, with and without rat liver S9	Mutagenic potency higher with S9, and potency on TA98 reached maximum of 309 rev/m^3. Maximum potency on TA98 without S9 ~106 rev/m^3. Potency without S9 dramatically reduced on TA98NR and TA98/1,8-DNP_6 compared with parent strain	Adonis & Gil (1993)
Santiago, Chile (1991)	Airborne PM from an urban, site, collected on GFFs with high-volume sampler. DCM sonication extraction	TA98, plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Higher potency (per m^3) with S9. Maximum potency without S9 177 rev/m^3; with S9 166 rev/m^3	Adonis et al. (1997)
Santiago, Chile (1991)	Airborne PM from downtown area, collected on GFFs with high-volume sampler. DCM sonication extraction	TA98, plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Higher potency (per m^3) with S9 in winter; opposite in summer. Corresponds with elevated levels of PAHs in cold season. Maximum potency with S9 ~300 rev/m^3; without S9 ~100 rev/m^3	Gil & Adonis (1996)
Santiago, Chile (1994)	Airborne PM from downtown area and rural control, collected on Teflon filters with low-flow sampler. DCM sonication extraction	TA98, microsuspension assay, with and without rat liver S9	Mutagenic potency (per m^3) at urban site higher without S9; at rural site higher with S9. Maximum potency with S9 ~2100 rev/m^3; without S9 ~2800 rev/m^3	Gil et al. (1997)

Supplemental Table S6 (continued)

Geographical location	Test article	*Salmonella* strains[a]/assay version	Results	Reference
Santiago, Chile (1996, 1997)	PM_{10} from several urban, residential, and industrial sites, collected on quartz filters with high-volume sampler. DCM sonication extraction	TA98, TA100, pre-incubation assay, with and without rat liver S9	Mutagenic potency (per m^3) frequently higher without S9; highest values for Santiago on TA100 without S9 (~140 rev/m^3). Potency on TA98 without S9 ~67 rev/m^3 for Santiago; with S9 ~60 rev/m^3. Strong correlation between activity on TA98 with S9 and PAH concentration	Koyano et al. (2002)
Pamplona, Colombia (2010)	$PM_{2.5}$ from an urban location, collected on GFFs. DCM Soxhlet extraction	TA98, TA100, plate incorporation assay, with rat liver S9	Significant mutagenic activity (per µg of EOM) with responses up to 10-fold above control. Responses higher on TA98	Melendez-Gelvez et al. (2012)
La Plata, Argentina (1994)	TSP from an urban/industrial location, collected on GFFs with high-volume sampler. Hx Soxhlet extraction	TA98, TA100, plate incorporation assay, with Aroclor 1254-induced rat liver S9	Mutagenic potency (per mg of PM) higher on TA98; elevated in autumn and winter, compared with summer. Increased potency corresponded to increase in PAHs	Müller et al. (2001)
La Plata, Argentina (1992)	TSP and PM_{10} from an industrial location, collected on GFFs with high-volume sampler. Hx Soxhlet extraction	TA98, TA100, plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Mutagenic potency (per mg of PM) highest on TA100 with S9. Potency of TSP higher than that of PM_{10}	Alzuet et al. (1996)
La Plata, Argentina (2000)	PM_{10} from 3 industrial locations, collected with cascade impactor. ASE with Hx	TA98, plate incorporation assay, with rat liver S9	Mutagenic potency (per mg of PM) associated with fine PM (< 1.5 µm) and ultrafine PM (< 0.49 µm). Potency (per m^3) of ultrafine fraction 10-fold higher than that of larger PM (0.49–3.0 µm). Potency highest at industrial site in winter. Mutagenic potency with S9 correlated with levels of PAHs. Maximum potency S9 ~1.2 rev/m^3	Massolo et al. (2002)

[a] YG1021: TA98 with plasmid pYG216, NR-overproducing strain; YG1024: TA98 with plasmid pYG219, OAT-overproducing strain; YG1041: TA98 with plasmid pYG233, NR- and OAT-overproducing strain; YG1026: TA100 with plasmid pYG216, NR-overproducing strain; YG1029: TA100 with plasmid pYG219, OAT-overproducing strain; YG1042: TA100 with plasmid pYG233, NR- and OAT-overproducing strain.

Ac, acetone; ASE, accelerated solvent extraction; CX, cyclohexane; DCM, dichloromethane; EOM, extractable organic matter; GFFs, glass-fibre filters; Hx, hexane; MeOH, methanol; NR, nitroreductase; OAT, *O*-acetyltransferase; PAHs, polycyclic aromatic hydrocarbons; PM, particulate matter; PM_{10}, particulate matter with particles of aerodynamic diameter < 10 µm; $PM_{2.5}$, particulate matter with particles of aerodynamic diameter < 2.5 µm; rev, revertants; TSP, total suspended particles.

Supplemental Table S7 Summary of studies that used bacterial mutagenicity assays (e.g. Ames assay) to assess the ability of outdoor air to induce genetic mutations – Europe

Geographical location	Test article	*Salmonella* strains[a]/assay version	Results	Reference
Rijnmond area, Netherlands	Airborne PM collected on GFFs with high-volume sampler. Soxhlet extraction with MeOH, CX, BZ, or Ac, liquid–liquid fractionation	TA98, TA100, standard plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Increased potency (per m^3 equiv) with S9. Polar solvent confirmed as satisfactory for PM mutagen extraction. Higher potency for samples collected downwind of urban/industrial areas (~40–60 rev/m^3), relative to locations influenced by sea air. Maximum potency on TA98 without S9 ~50 rev/m^3; with S9 ~60 rev/m^3	de Raat (1983)
Rijnmond area, Netherlands (1981)	Airborne PM from 5 locations, collected on GFFs with high-volume sampler. MeOH:Ac (1:1) Soxhlet extraction	TA98, TA100, standard plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Strong influence of location and wind direction on potency (per m^3). Potency lower when wind from south-west (from sea). Highest potency for urban/industrial locations. Most samples more potent with S9. Follow-up work showed correlations between mutagenic activity and PAH concentration	de Raat et al. (1985, 1987)
Rijnmond area, Netherlands (1982)	Airborne PM from 3 locations, collected on GFFs with high-volume sampler. MeOH Soxhlet extraction	TA98, TA98NR, standard plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Mutagenic potency (per m^3) generally elevated without S9; somewhat higher at location downwind of major roadway. Significant decline in activity on TA98NR relative to TA98. Diurnal trend, with decreasing potency with S9 between morning and evening. Elevated activity corresponded with winds from south-west (Rotterdam). Maximum potency on TA98 without S9 ~58 rev/m^3; with S9 ~63 rev/m^3	de Raat & de Meijere (1988)
Rijnmond area, Netherlands	Airborne PM and SVOCs from 2 locations, collected on GFFs and PUFs. MeOH or Ac Soxhlet extraction	TA98, standard plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Mutagenic potency (per m^3) of PM extracts far exceeded that of PUF extracts, which yielded false positives. Potency of PM from more-urban sites higher with S9; opposite for less-urban location. Maximum potency on TA98 without S9 ~35 rev/m^3; with S9 ~38 rev/m^3	de Raat et al. (1987)
Maastricht, Netherlands	TSP, PM_{10}, and $PM_{2.5}$ from 6 locations with pronounced differences in traffic, collected on GFFs with high-volume sampler. DCM Soxhlet extraction	TA98, pre-incubation assay, with and without rat liver S9	Mutagenic potency (per mg of PM) generally elevated without S9; $PM_{2.5}$ higher than PM_{10} or TSP. Some correspondence with traffic density, except city periphery, more-rural location	de Kok et al. (2005)
Several locations, Netherlands (1985–1986)	Airborne PM from 4 urban locations and 1 rural location, collected on GFFs with high-volume sampler. MeOH Soxhlet extraction, extensive fractionation	TA98, TA98NR, TA98/1,8-DNP_6, TA100, TA97, standard plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Mutagenic potency (per m^3) of crude extract higher with S9. Strong contributions of mono-nitroarene fractions to activity without S9 (~24%). PAH fraction accounted for ~5% of activity with S9. Substantial reduction in activity on TA98NR, relative to TA98. Maximum potency on TA98 with S9 ~43 rev/m^3; without S9 ~26 rev/m^3	de Raat et al. (1994)

Supplemental Table S7 (continued)

Geographical location	Test article	*Salmonella* strains[a]/assay version	Results	Reference
Wageningen and Terschelling, Netherlands (1979–1980)	Airborne PM from 2 rural sites, collected on GFFs with high-volume sampler. MeOH Soxhlet extraction	TA98, standard plate incorporation assay, with and without Aroclor 1254-induced liver S9	Monitoring for a year. Similar potency (per m^3) with and without S9. Marked day-to-day variability, but generally higher values in autumn, relative to summer. Potency heavily influenced by wind direction; winds from east and south-east (i.e. Germany and Belgium) associated with higher potency. Maximum potency on TA98 without S9 ~20 rev/m^3	Alink et al. (1983)
Wageningen, Netherlands (1982–1983)	PM collected by local meteorological station, on GFFs. MeOH Soxhlet extraction	TA98, standard plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Potency (per m^3) of outdoor samples from a rural town elevated with S9. Potency on TA98 without S9 ~5 rev/m^3; with S9 ~7 rev/m^3	van Houdt et al. (1984)
Wageningen, Netherlands (1988–1990)	PM collected by local meteorological station, on GFFs. MeOH Soxhlet extraction	TA98, standard plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Mutagenic potency (per m^3) higher with S9 when wind from south; higher without S9 when wind from north-west and air quality improved. Maximum potency on TA98 with S9 ~10 rev/m^3; without S9 ~8 rev/m^3	Heussen (1991)
Wageningen and Terschelling, Netherlands (1979–1985)	Airborne PM collected from a rural town and an island, collected on GFFs with low- or high-volume sampler. MeOH Soxhlet extraction	TA98, standard plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Mutagenic potency (per m^3) elevated with S9 and generally higher in autumn and winter months. Potency of samples from background site (Terschelling) frequently exceeded that for rural site (Wageningen). Maximum potency on TA98 with S9 ~35 rev/m^3; without S9 ~18 rev/m^3. Negative correlation between potency and temperature; positive correlation with NO_2, SO_2, and CO. Strong influence of wind direction and air mass trajectory	van Houdt et al. (1987)
Wageningen, Netherlands	PM collected by local meteorological station. MeOH Soxhlet extraction	TA98, standard plate incorporation assay, with and without induced and uninduced rat liver S9, induced and uninduced mouse liver S9, mouse and rat lung S9	Potency (per m^3) elevated with S9 and far higher in winter than in summer. Maximum potency with S9 ~12 rev/m^3; negligible potency without S9. Highest activity with induced rat liver S9. Lung S9 results similar to those for uninduced liver	van Houdt et al. (1988)
Liège, Belgium (1980)	Airborne PM, collected on GFFs with high-volume sampler. Extraction with BZ, fractionation on silica	TA98, TA100, standard plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Mutagenic activity (per µg of EOM) on TA98 higher without S9; slight elevation with S9 on TA100. Highest activity in aromatic fraction; elevated with S9. Substantial activity in polar fraction without S9	de Wiest et al. (1982)

Supplemental Table S7 (continued)

Geographical location	Test article	*Salmonella* strains[a]/assay version	Results	Reference
Flanders, Belgium (2000)	PM_{10} from urban, rural, and industrial sites, collected on GFFs with low-volume sampler. ASE with THF/Hx (20:80), or aqueous PM_{10} suspension	TA98, standard plate incorporation assay, with and without rat liver S9	Highest potency for PM_{10} extract from urban site with S9. Without S9, only the highest concentration (m^3 equiv) elicited a positive response for the urban and industrial locations. With S9, both the PM_{10} suspensions and the PM_{10} extracts elicited positive responses. Urban PAH concentration (ng/m^3) higher than for rural and industrial sites	Brits et al. (2004)
Flanders, Belgium (2000–2001)	PM_{10} and SVOCs from urban, rural, and industrial sites; PM collected on quartz filters and SVOCs on PUFs with high-volume sampler. Ac Soxhlet extraction	TA98, standard plate incorporation assay, with and without rat liver S9	Winter PM extracts from all sites more potent (per m^3 equiv and per µg of PM) with S9. PM extracts for summer samples generally less potent (per m^3 equiv and per µg of PM) than winter samples. PUF extracts generally more potent (per m^3 equiv) with S9, and frequently more potent in summer. Combined (PUF + PM) activity significantly higher in winter than in summer. Total potency with S9 (per m^3) empirically related to PAH concentration. Maximum potency on TA98 ~60 rev/m^3 without S9; ~97 rev/m^3 with S9	Du Four et al. (2004)
Flanders, Belgium (2002)	PM_{10} and SVOCs from 15 urban, rural, and industrial sites; PM collected on quartz filters and SVOCs on PUFs with high-volume sampler. Ac Soxhlet extraction	TA98, standard plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Metabolic activation contributed to an increase in potency (per m^3) for SVOCs; similar responses with and without S9 for PM samples. Potency somewhat elevated at urban sites and industrial area with known point sources, but highest potency at rural site. Maximum potency on TA98 ~47 rev/m^3 without S9 and ~43 rev/m^3 with S9 for PM extracts; ~11 rev/m^3 without S9 and ~30 rev/m^3 with S9 for SVOCs	Du Four et al. (2005)
Several locations in Finland (1985)	Airborne PM and SVOCs collected in Helsinki, Lahti, and Ätäri with high-volume sampler; PM collected on filter, SVOCs on XAD-2 resin. Ac extraction, fractionation on silica	TA98, TA100, TA98NR, standard plate incorporation assay, with and without PB/5,6-BF-induced rat liver S9	For rural reference site (Ätäri), minimal or no mutagenic activity. Potency (per m^3) higher with S9. For Helsinki, SVOCs and PM extracts similar in summer; SVOCs higher in winter. Potency on TA98NR substantially reduced relative to TA98. Potency on TA98 ~2–10 rev/m^3 with S9; ~1–8 rev/m^3 without S9. Most polar fraction generally showed highest potency	Tuominen et al. (1988)
Coastal area in central Finland (1985)	Airborne PM and SVOCs collected in Kokkola with high-volume sampler; PM collected on filter, SVOCs on XAD-2 resin. Ac extraction, fractionation on silica	TA98 and TA100, standard plate incorporation assay, with and without PB/5,6-BF-induced rat liver S9	Mutagenic activity in both PM and vapour-phase extracts. Similar potency (per m^3 equiv) on TA98 with and without S9. Potency at urban site higher without S9. Significant response for polar (e.g. nitro-PAH) fraction from urban sample only. Potency on TA98 ~3 rev/m^3 with S9; ~2 rev/m^3 without S9	Pyysalo et al. (1987)

Supplemental Table S7 (continued)

Geographical location	Test article	*Salmonella* strains[a]/assay version	Results	Reference
Oslo, Norway (1981)	Airborne PM and SVOCs from 2 urban sites, collected on GFFs and XAD-2 with high-volume sampler. Ac Soxhlet extraction	TA98, standard plate incorporation assay, with and without Aroclor 1254-induced liver S9	All XAD extracts more potent (per m^3) without S9. Similar potency (per m^3) of PM extracts with and without S9. Percentage of total activity on XAD increased with increasing temperature. No relationship between mutagenic activity and PAH concentration. Maximum potency on TA98 ~136 rev/m^3 with S9; ~57 rev/m^3 without S9	Alfheim et al. (1985)
Oslo, Norway (1978)	Airborne PM from 2 urban sites, collected on GFFs and XAD-2 with high-volume sampler. CX Soxhlet extraction	TA98, standard plate incorporation assay, with and without Aroclor 1254-induced liver S9	Mutagenic potency (per m^3) frequently elevated with S9; generally higher in winter than in spring. Potency (per m^3) similar for both sites; potency on TA98 per mg of PM 2-fold higher at industrial site compared with heavy-traffic site. Strong influence of meteorological conditions, and diurnal changes in mutagenic potency followed changes in SO_2. Maximum potency on TA98 without S9 ~12 rev/m^3; with S9 ~11 rev/m^3	Møller & Alfheim (1980)
Oslo, Norway (1979)	Airborne PM from 2 urban sites, collected with cascade impactor. Ac Soxhlet extraction	TA98, standard plate incorporation assay, with and without Aroclor 1254-induced liver S9	Mutagenic potency (per m^3) on TA98 of street-level samples higher with S9; rooftop samples sometimes higher without S9. Night-time samples generally far less potent than daytime samples. Maximum potency on TA98 without S9 ~45 rev/m^3; with S9 ~180 rev/m^3. Mutagenic activity of street samples related to traffic intensity and CO, NO, and PAH levels. Activity with S9 associated with acidic and neutral–aromatic fractions	Møller et al. (1982)
Scandinavia (1979–1981)	Airborne PM from 5 locations in Sweden and 8 locations in Norway, collected on GFFs with high-volume sampler or cascade impactor. Ac Soxhlet extraction, acid–base–neutral fractionation	TA98, TA98NR, TA98/1.8-DNP_6, YG1021, YG1024, standard plate incorporation assay, with and without Aroclor 1254-induced liver S9	Elevated mutagenic potency (per m^3) without S9 for Stockholm; elevated potency with S9 for Oslo. Substantial increases in winter, and higher potency for urban areas relative to background. Highest mutagenic potency for PM < 0.5 µm. Potency reductions on NR- and OAT-impaired strains. Reduced potency for samples collected at high elevations. Fractionation showed high activity without S9 for fractions containing polar compounds (e.g. ketones, quinones, acids, and N-heterocyclics). Maximum potency ~68 rev/m^3 without S9 (Stockholm); ~180 rev/m^3 with S9 (Oslo)	Alfheim et al. (1983)
Sundsvall, Sweden (1981)	Airborne PM from 4 sites near aluminium smelting plant, collected on GFFs with high-volume sampler. Ac Soxhlet extraction	TA98, TA100, TA98NR, standard plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Mutagenic potency (per m^3) comparable to other Scandinavian urban areas, and marginal influence of aluminium smelter. Similar responses with and without S9. Similar responses for winter and summer. Decreased potency without S9 on TA98NR relative to TA98. Maximum potency ~20 rev/m^3 without S9; ~22 rev/m^3 with S9	Alfheim et al. (1984)

Supplemental Table S7 (continued)

Geographical location	Test article	*Salmonella* strains[a]/assay version	Results	Reference
Stockholm, Sweden	Airborne PM from city centre, collected on GFFs with high-volume sampler. DCM Soxhlet extraction, fractionation on silica	TA98, TA98NR, standard plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Analysis of subfractions of moderately polar fraction indicated activity without S9 for polar fractions containing aromatic acids and ketones. Substantial reduction of subfraction mutagenicity on TA98NR, relative to TA98. Maximum potency without S9 ~30 rev/m^3; with S9 ~94 rev/m^3	Strandell et al. (1994)
Gothenburg, Sweden (1981–1984)	Airborne PM from 13 locations including tunnel, collected on GFFs, electrostatic precipitator and consecutive high-volume sampler. Ac Soxhlet extraction	TA96, TA98, TA100, TA102, TA104, TA98NR, TA98/1.8-DNP$_6$, standard plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Mutagenic potency (per m^3) on TA98 of most samples higher without S9; tunnel samples higher with S9. Generally higher potency (per mg of PM) in winter, except for tunnel samples. Urban samples generally more potent (per m^3) than coastal samples. Maximum potency on TA98 without S9 ~130 rev/m^3; with S9 ~110 rev/m^3. Potency (per mg of PM) substantially reduced on NR- and OAT-deficient strains	Löfroth et al. (1985), Alfheim & Lindskog (1984)
Copenhagen, Denmark (1988)	Airborne PM from 10 suburban locations, collected on GFFs with high-volume sampler. Separate DCM and Ac sonication extraction	TA98 and TA98NR, standard plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Similar potency on TA98 (per m^3) with and without S9 for both solvents. Some samples showed increased activity for Ac extract. Reduced potency on TA98NR relative to TA98. Average potency of DCM extract significantly higher for TA98NR. Maximum potency on TA98 without S9 ~19 rev/m^3; with S9 ~20 rev/m^3	Nielsen (1992)
Copenhagen, Denmark (1981)	Airborne PM from 2 urban sites, collected on GFFs with high-volume sampler. Sequential Soxhlet extraction with CX and MeOH, detailed fractionation	TA1537, TA1538, TA100, TA1535, plate incorporation assay, with and without PB/5,6-BF-induced rat liver S9	Mutagenic potency of PAH fraction on TA1538 without S9 (per m^3) higher at street level than at rooftop (22 m). Height effect less pronounced for polar fraction. Maximum potency on TA1538 ~22 rev/m^3 without S9. Potency of PAH fraction from street level correlated with lead levels	Madsen et al. (1982)
Copenhagen, Denmark	Airborne PM from urban site and reference, collected with electrostatic sampler. ASE with Hx:Ac (1:1), fractionation on silica	TA98, YG5161, YG1041, microsuspension assay, with and without Aroclor 1254-induced rat liver S9	Mutagenic potency (per mg of PM) higher without S9, with little difference between urban site and reference site. Higher potency on YG1041, particularly for polar fraction without S9. No increase in potency on YG5161, relative to TA98	Sharma et al. (2007)
Copenhagen, Denmark (1996, 1998)	Airborne PM from urban and semi-rural sites, collected on GFFs with high-volume sampler. Sequential sonication extraction with DCM and Ac	TA98, TA98NR plate incorporation assay, with and without rat liver S9	Mutagenic potency (per m^3) higher with S9; for rural site, higher without S9. Degree of contribution of PAHs influenced by air mass movement. Air masses from central Europe enriched in mutagenic activity, PAHs, and nitro-PAHs. Maximum potency on TA98 with S9 ~335 rev/m^3; without S9 ~150 rev/m^3	Feilberg et al. (2002)

Supplemental Table S7 (continued)

Geographical location	Test article	*Salmonella* strains[a]/assay version	Results	Reference
Bohemia region, Czech Republic (2000–2001)	PM_{10} from 3 sites in northern Bohemia, collected on GFFs with high-volume sampler. DEE:Hx (1:9) Soxhlet extraction	TA98, YG1041, standard plate incorporation assay, with and without Delor 103 (PCB)-induced rat liver S9	Significant elevation in potency (per m^3) for winter for both strains with and without S9. Increase in potency on TA98 with S9. YG1041 more potent without S9. No significant difference in potency (per m^3) across sites. Significant correlation between potency on TA98 with S9 (per µg of EOM) and potency on YG1041 with and without S9 (per µg of EOM) and levels of PAHs. Maximum potency on TA98 without S9 ~12 rev/m^3; with S9 ~25 rev/m^3	Binková et al. (2003)
Bohemia region, Czech Republic (1996–1997)	PM_{10} from polluted location in northern Bohemia and rural control, collected on GFFs with high-volume sampler. DCM Soxhlet extraction, acid–base–neutral fractionation	TA98, YG1041, standard plate incorporation assay, with and without Delor 103 (PCB)-induced rat liver S9	Mutagenic potency (per m^3) marginally higher at polluted site; elevated in winter, and higher in winter with S9. Potency of winter samples from less-polluted site higher without S9. Marked increase in potency on YG1041, relative to TA98. Maximum potency on TA98 without S9 ~24 rev/m^3; with S9 ~30 rev/m^3. Significant contribution (25–50%) of acidic compounds to activity without S9	Cerná et al. (2000)
Bohemia region, Czech Republic (1996–1997)	PM_{10} from 2 heavy-traffic locations and 2 rural locations, collected on GFFs with high-volume sampler. DCM sonication extraction	TA98, YG1041, microsuspension and plate incorporation assays, with and without Delor 103 (PCB)-induced rat liver S9	Mutagenic potency (per m^3 or per µg of EOM) significantly higher in winter. Significant increase in potency on YG1041 relative to TA98. Microsuspension results did not show the same increases in potency in winter. Higher potency at industrial and high-traffic locations. Correlation between mutagenic activity and carcinogenic PAHs. Maximum potency (plate incorporation) on TA98 without S9 ~107 rev/m^3; with S9 ~85 rev/m^3	Cerná et al. (1999)
Brno, Czech Republic (2001)	PM_{10}, TSP, and SVOCs from 2 urban sites, collected on Teflon-coated filters, GFFs, and PUFs with high-volume sampler. DCM Soxhlet extraction, fractionation on silica	TA98, YG1041, standard plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Mutagenic potency (per m^3) higher with S9; 15–40% of total activity associated with SVOCs. Maximum potency of PM_{10} on TA98 ~10 rev/m^3 with S9; ~7 rev/m^3 without S9. Substantial increase in potency without S9 on YG1041, compared with TA98	Ciganek et al. (2004)
Czech Republic (1999–2003)	Airborne PM from 4 towns with different levels of industrial and commercial activities, collected on GFFs with high-volume sampler. DCM sonication extraction	TA98, YG1041, standard plate incorporation assay, with and without rat liver S9	Mean mutagenic potency (per m^3) higher with S9; elevated at heavy-traffic urban location (Prague). Significant elevation on NR- and OAT-enhanced strain without S9, relative to TA98 (100-fold). Maximum potency on TA98 ~41 rev/m^3 with S9; ~24 rev/m^3 without S9. Correlation between mutagenic activity and PAH levels	Pastorková et al. (2004)
Wrocław, Poland (2007)	PM_{10} and $PM_{2.5}$ from an urban site, collected on sintered glass filters. DCM Soxhlet extraction, fractionation on silica	TA98, TA100, YG1041, YG1042, plate incorporation assay, with and without rat liver S9	Enhanced potency (per m^3) for PM_{10}, relative to $PM_{2.5}$. $PM_{2.5}$ potency reduced with S9. PM_{10} potency similar with and without S9. Potency with and with S9 increased on YG1041 and YG1042, relative to parent strains. Maximum potency on TA98 ~4 rev/m^3 with S9; ~50 rev/m^3 without S9	Piekarska (2009)

Supplemental Table S7 (continued)

Geographical location	Test article	*Salmonella* strains[a]/assay version	Results	Reference
Wrocław, Poland (2007)	PM_{10} from an urban site, collected on sintered glass filters. DCM Soxhlet extraction, fractionation on silica	TA98, YG1041, plate incorporation assay, with and without rat liver S9	Potency (per m^3) higher without S9 and higher in winter than in summer. Increased potency on YG1041, particularly for winter samples. High mutagenic activity in winter fractions containing nitro-PAHs and summer fractions containing nitro-PAHs and dinitro-PAHs. Maximum potency on TA98 ~20 rev/m^3 with S9; ~30 rev/m^3 without S9	Piekarska et al. (2009)
Wrocław, Poland (1997–1998)	PM_{10} from an urban site, collected on GFFs. DCM Soxhlet extraction, fractionation on silica	TA98, YG1021, YG1024, plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Mutagenic potency (per mg of PM) elevated with S9 and elevated in winter compared with summer. Elevated activity on YG1021 and YG1024, relative to TA98, with highest activity in aromatic and polar fractions	Jadczyk & Kucharczyk (2005), Zwodziak et al. (2001)
Wrocław, Poland	Airborne PM from an urban site, collected on GFFs. DCM Soxhlet extraction	TA98, TA100, YG1041, YG1042, plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Mutagenic potency (per m^3) on TA98 elevated without S9 for winter. Similar responses with and without S9 for summer. Highest responses on YG1041 with S9. Maximum potency on TA98 without S9 ~24 rev/m^3; with S9 ~12 rev/m^3	Piekarska & Karpińska-Smulikowska (2007)
Wrocław, Poland	Airborne PM from an urban site, collected on GFFs. DCM Soxhlet extraction	TA98, YG1041, plate incorporation assay, with and without Aroclor 1254- or PB-induced rat liver S9	Mutagenic potency (per m^3) higher for winter. Higher activity without S9 for winter only. Similar potency for Aroclor- and PB-induced S9. Dramatic increase in potency on YG1041, relative to TA98. Maximum potency on TA98 without S9 ~11 rev/m^3; with S9 ~15 rev/m^3	Piekarska & Karpińska-Smulikowska (2006)
Wrocław, Poland (2007)	PM_{10} from an urban site, collected on sintered glass filters. DCM Soxhlet extraction	TA98, TA100, YG1041, YG1042, plate incorporation assay, with and without rat liver S9	Higher mutagenic potency (per m^3) without S9 and elevated in autumn (~5-fold), relative to summer. Maximum potency on TA98 without S9 ~17 rev/m^3; with S9 ~11 rev/m^3. Highest responses on YG1041	Piekarska (2010)
Wrocław, Poland	Airborne PM from 2 urban sites, collected on glass filters. DCM Soxhlet extraction	TA98, YG1041, plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Mutagenic potency (per m^3) on TA98 higher without S9, elevated in winter, and higher at heavy-traffic site. Potency elevated on YG1041, relative to TA98. Maximum potency on TA98 without S9 ~150 rev/m^3; with S9 ~300 rev/m^3	Piekarska et al. (2011)
Wrocław, Poland (1997–1998)	Airborne PM from an urban location, 12 composite monthly samples, collected on GFFs. DCM Soxhlet extraction	TA98, standard plate incorporation assay, with and without rat liver S9	All samples elicited significant positive responses. Frequently higher responses with S9 activation, highest responses in winter months. Far smaller winter sample (m^3 equiv) required to elicit a positive response. Maximum potency on TA98 without S9 ~6 rev/m^3; with S9 ~10 rev/m^3	Jadczyk & Kucharczyk (2000)

Supplemental Table S7 (continued)

Geographical location	Test article	*Salmonella* strains[a]/assay version	Results	Reference
Silesia, Poland (1984–1985)	Airborne PM from 23 locations, collected on GFFs with high-volume sampler. BZ Soxhlet extraction, fractionation on silica	TA100, plate incorporation assay, with and without rat liver S9	Mutagenic potency (per mg of EOM) enhanced with S9 for moderately polar fractions (e.g. PAHs and heterocyclics), particularly for winter months. Potency (per m^3) enhanced with S9 for winter months, but potency of more polar fractions equal with and without S9, or higher without S9. Maximum potency with and without S9 ~200 rev/m^3. Increased potency with decreasing temperature	Motykiewicz et al. (1989)
Silesia, Poland (1987)	Airborne PM from 20 locations, collected on GFFs with high-volume sampler. CX Soxhlet extraction	TA98, TA100, plate incorporation assay, with and without rat liver S9	Mutagenic potency (per m^3) on TA98 elevated with S9, particularly in winter. Potency on TA100 generally higher in winter, especially without S9. Maximum potency on TA98 with S9 ~90 rev/m^3; without S9 ~32 rev/m^3. Potency inversely correlated with temperature	Motykiewicz et al. (1985, 1990)
Ajka and Pápa, Hungary (1982–1984)	Airborne PM from highly polluted Ajka and non-industrial Pápa, collected on GFFs with high-volume sampler. BZ:Ac (19:1) Soxhlet extraction or DCM sonication extraction	TA98, TA100, plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Mutagenic potency (per mg of PM) highest on TA98 with S9, and potency 3–9-fold higher in winter compared with summer. Winter values at non-industrial site higher than at industrial site, but potency (per m^3) higher at industrial site. Maximum potency on TA98 with S9 ~32 rev/m^3	Pintér et al. (1990), Török et al. (1989)
Leipzig, Germany (2000)	PM_{10} from 2 urban locations, collected with cascade impactor. ASE with Hx	TA98, plate incorporation assay, with rat liver S9	Mutagenic potency (per mg of PM) associated with fine PM (< 1.5 µm) and ultrafine PM (< 0.49 µm). Potency (per m^3) of ultrafine fraction 10-fold higher than that of larger PM (0.49–3.0 µm). Potency generally higher in winter. Mutagenic potency with S9 correlated with levels of PAHs. Maximum potency with S9 ~0.1 rev/m^3	Massolo et al. (2002)
Berlin, Germany (1980–1981)	Airborne PM from 3 locations, collected with cascade impactor. Soxhlet or sonication extraction with CX	TA98, plate incorporation assay, with rat liver S9	Mutagenic potency (per m^3) at the suburban site showed strong winter peak and decline in spring. Industrial and urban sites showed a decline in summer. Maximum potency with S9 ~14 rev/m^3. PAH concentration ratios suggest domestic heating emissions in winter. Correlation between mutagenic potency and SO_2 levels	Israël & Busing (1983)
Berlin, Germany	TSP collected during a 4 day smog event. CX extraction	TA98, plate incorporation assay, with rat liver S9	Mutagenic potency (per m^3) during smog event > 4-fold higher than other outdoor measurements. Maximum potency ~265 rev/m^3	Israel et al. (1984)
Berlin, Germany (1983–1984)	Airborne PM from 2 urban sites, collected with cascade impactor. CX:DEE (2:8) sonication extraction, acid–base–neutral fractionation	TA98, TA100, TA98NR, plate incorporation assay, with and without rat liver S9	Mutagenic potency (per m^3) higher with S9; higher on TA98 than on TA100. Maximum potency with S9 ~80 rev/m^3; without S9 ~41 rev/m^3. Marked decline in potency during summer. Higher potency at residential site. Highest activity in neutral polar organic fraction. Marked decrease on NR-deficient strain, particularly for polar fraction	Moriske et al. (1985)

Supplemental Table S7 (continued)

Geographical location	Test article	*Salmonella* strains[a]/assay version	Results	Reference
Berlin, Germany (1983–1985)	Airborne PM from 2 urban sites and a highway tunnel, collected with cascade impactor. CX:DEE (2:8) sonication extraction, acid–base–neutral and TLC fractionation	TA98, TA98NR, plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	For urban sites and highway tunnel, mutagenic potency (per µg of EOM) higher with S9 and elevated in neutral and acid fractions. Highest activity in polar organic fraction. Activity of fractions from tunnel samples showed 10–25% reduction on TA98NR compared with TA98	Moriske & Rüden (1988)
Berlin, Germany (1981–1982)	Airborne PM collected with cascade impactor. DEE:BZ (9:1) sonication extraction	TA98, TA100, plate incorporation assay, with and without rat liver S9	Mutagenic potency (per m^3) of 0.4–0.7 µm size fraction elevated with S9; higher in autumn and winter compared with spring and summer. Maximum potency on TA98 with S9 ~22 rev/m^3; without S9 ~11 rev/m^3	Wullenweber et al. (1982, 1984)
Berlin, Germany (1981)	Airborne PM collected with cascade impactor. DEE sonication extraction, polar organic and PAH fractions	TA98, TA100, plate incorporation assay, with and without rat liver S9	Mutagenic potency (per µg of EOM) much higher for polar aromatics compared with PAH fraction. Polar aromatics slightly elevated without S9; PAH fraction higher with S9. Higher mutagenic activity for smaller particles (0.4–1.3 µm), compared with particles of 1.3–10.2 µm. Maximum potency on TA98 with S9 ~8 rev/m^3; without S9 ~6 rev/m^3	Moriske et al. (1982)
Berlin, Germany (1981–1982)	Airborne PM collected with cascade impactor. DEE:BZ (9:1) sonication extraction, acid–base–neutral fractionation	TA98, plate incorporation assay, with and without rat liver S9	Mutagenic potency (per m^3) of ultrafine PM (< 0.4 µm) marginally higher without S9; significantly elevated in autumn and winter compared with summer. Some indication of reduced mutagenicity on weekends. Substantial portion of mutagenic activity in acidic (18–31%) and neutral (41–66%) fractions. Maximum potency on TA98 with S9 ~15 rev/m^3; without S9 ~17 rev/m^3	Gottlieb et al. (1983)
Herne, Germany (1977)	Airborne PM from urban site in Ruhr area, collected on polystyrene or cellulose nitrate filters. DCM or DEE extraction	TA98, plate incorporation assay, with and without PCB-induced mouse liver S9	Mutagenic potency (per µg of PM) higher with S9. Highest activity in PAH and polar fractions; ~30–50% of the activity does not require S9	Hoffmann et al. (1980)
Baden-Württemberg, Germany (1995)	Airborne PM from an urban, site, collected on GFFs with high-volume sampler. Ac Soxhlet extraction	Plate incorporation assay with Ames II base-pair substitution strains TA7001, TA7002, TA7003, TA7004, TA7005, TA7006, without S9 activation	Mutagenic potency (per m^3) enhanced on TA7005 (CG to AT transversions), TA7004 (CG to TA transitions), TA7002 (TA to AT transversions), and TA70006 (CG to GC transversions). Potency higher in winter	Erdinger et al. (2004)

Supplemental Table S7 (continued)

Geographical location	Test article	*Salmonella* strains[a]/assay version	Results	Reference
Baden-Württemberg, Germany (1993)	Airborne PM from 8 locations including a background forest site, collected on GFFs with high-volume sampler. Ac Soxhlet extraction	TA98, TA100, TA98NR, plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	No significant difference between potency (per m^3) with and without S9. Higher potency generally associated with more-congested urban sites; highest activity associated with a low-traffic site. Maximum potency on TA98 without S9 ~30–100 rev/m^3 for urban and suburban sites; ~10 rev/m^3 for background site. Significant but seasonally variable decrease on TA98NR; positive correlation between mutagenic activity and NO, NO_2, and SO_2	Erdinger et al. (2005)
Duisburg, Germany (~1977)	Airborne PM, Draeger Box Micron filter. MeOH extraction, fractionation on alumina	TA98, TA1537, TA1538, TA100, standard plate incorporation assay, with and without Clophen C-induced rat liver S9	Enhanced potency with S9, and highest potency for crude MeOH extract. Low activity in PAH-containing fraction, relative to crude extract	Dehnen et al. (1978)
Piedmont, Tuscany, and Sicily, Italy	PM_{10} and/or $PM_{2.5}$ from 5 locations, collected on GFFs with low-volume sampler. Ac Soxhlet extraction	TA98, TA100, plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Mutagenic potency (per m^3) higher without S9. Similar potency across sites, although slightly elevated at industrial and high-traffic site. $PM_{2.5}$ potency higher than site-matched PM_{10} potency. Maximum potency on TA98 ~8 rev/m^3 with S9; ~20 rev/m^3 without S9	Gilli et al. (2007c)
Bormida Valley, Italy (1989)	PM_{10} from 6 locations, collected on GFFs with high-volume sampler. Sequential Ac sonication and Soxhlet extraction	TA98, TA100, plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Mutagenic potency (per m^3) similar with and without S9. Significant negative relationship between mutagenic potency and air temperature, and significant positive relationship between potency and traffic density. Samples near industrial zone did not yield high potency values. Maximum potency on TA98 ~23 rev/m^3 with S9; ~24 rev/m^3 without S9	Scarpato et al. (1993)
La Spezia, Italy (1988)	Airborne PM from an urban location, collected on GFFs, with high-volume sampler. CX sonication extraction, PAH-containing TLC fraction	TA98, TA98NR, TA98/1,8-DNP_6, plate incorporation assay, with and without PB/5,6-BF-induced rat liver S9	Mutagenic potency (per m^3) higher with S9, and positively correlated with PAH concentration. Mutagenic potency and PAH concentration declined with increasing air temperature. No appreciable differences on TA98NR and TA98/1,8-DNP_6, relative to TA98. Maximum potency on TA98 ~17 rev/m^3 with S9; ~3 rev/m^3 without S9	Barale et al. (1991a)
Brescia, Italy (1991)	PM_{10} from a residential area, collected on GFFs with cascade impactor. DCM Soxhlet extraction	TA98, TA98/1,8-DNP_6, microsuspension assay, with and without Aroclor 1254-induced rat liver S9	Mutagenic potency (per mg of EOM or m^3) similar with and without S9 for PM of 0.5–10 µm. PM < 0.5 µm more potent than larger PM and more potent without S9. Substantial potency reduction on TA98/1,8-DNP_6 compared with TA98. Maximum potency on TA98 ~5 rev/m^3 with S9; ~4 rev/m^3 without S9	Monarca et al. (1997)
Unidentified town, Italy	Airborne PM from a mid-sized town, collected on GFFs with high-volume sampler. Ac Soxhlet extraction	TA98, TA98NR, plate incorporation assay, without Aroclor 1254-induced rat liver S9	Higher potency (per m^3) with S9, and elevated in autumn and winter. Maximum potency ~40 rev/m^3 with S9; ~35 rev/m^3 without S9. Substantial reductions in potency on TA98NR relative to TA98	Morozzi et al. (1992)

Supplemental Table S7 (continued)

Geographical location	Test article	*Salmonella* strains[a]/assay version	Results	Reference
Several towns, Italy (1988)	PM_{10} from 11 towns, collected on GFFs with high-volume sampler. Ac sonication extraction	TA98, TA100, TA98NR, TA100NR, plate incorporation assay, with and without PB/5,6-BF-induced rat liver S9	Average TA98 mutagenic potency (per m^3) mostly higher without S9. Significant correlations between TA98 activity with and without S9 and NO_2, CO, and NMHC. Maximum potency on TA98 ~280 rev/m^3 without S9; ~20 rev/m^3 with S9. Substantial reductions of NR-deficient strains	Barale et al. (1991b)
Several towns, Italy (1990)	PM_{10} from 17 towns, collected on GFFs with high-volume sampler. DCM sonication extraction, acid–base–neutral fractionation, TLC fractionation	TA98, TA98NR, TA98/1,8-DNP_6, plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Mutagenic potency (per m^3) generally modestly elevated with S9; potency generally higher at colder temperatures. Potency positively correlated with lead levels. Acid and polar fraction generally showed higher activity, and potency reduced 20–38% on TA98NR and 48–77% on TA98/1,8-DNP_6, relative to TA98. Maximum potency on TA98 without S9 ~100 rev/m^3; without S9 ~150 rev/m^3	Barale et al. (1994)
Pisa, Italy (1986–1987)	Airborne PM from 5 locations in a non-industrial town, collected on GFFs with high-volume sampler. Ac Soxhlet extraction	TA98, TA100, pre-incubation assay, with and without PB/5,6-BF induced mouse liver S9	Mutagenic potency (per m^3) higher with S9; potency without S9 significantly elevated in autumn and winter. Potency (per µg of PM) on TA98 without S9 significantly elevated in autumn and winter. Potency (per m^3) generally lower at rural site; higher but variable at sites with moderate to heavy traffic. Maximum potency on TA98 without S9 ~140 rev/m^3; without S9 ~28 rev/m^3	Barale et al. (1989)
Pisa, Italy (1993–1994)	Airborne PM from 2 locations, collected on cellulose nitrate filter with low-volume sampler. Sequential extraction with DCM and MeOH	TA98, TA100, plate incorporation assay, without rat liver S9	Significant response only for high-traffic site, and mutagenic activity higher with S9. Similar responses in summer and autumn. Maximum potency on TA98 without S9 ~80 rev/m^3; with S9 ~180 rev/m^3	Bronzetti et al. (1997)
Pisa, Italy	Airborne PM from 3 urban locations, collected on GFFs. Sequential sonication extraction with DCM and Hx	TA98, TA100, plate incorporation assay, with and without PB/5,6-BF-induced mouse liver S9	Mutagenic potency (per m^3) generally higher at higher-traffic location. Potency generally higher with S9 in autumn and winter; without S9 in summer. Maximum potency on TA98 without S9 ~33 rev/m^3; with S9 ~33 rev/m^3	Vellosi et al. (1994)
Turin, Italy (2001–2004)	$PM_{2.5}$ from a high-traffic location, collected on Teflon filters with high-volume sampler. Ac Soxhlet extraction	TA98, TA100, plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Mean mutagenic potency (per m^3) higher without S9. Pooled monthly samples showed elevated potency in autumn and winter compared with summer, and this corresponds to higher $PM_{2.5}$ levels. Some positive correlations between mutagenic potency and PAH levels. Maximum potency on TA98 without S9 ~100 rev/m^3; with S9 ~35 rev/m^3	Gilli et al. (2007a)
Turin, Italy (2003–2004)	PM_{10} from an urban site, collected on GFFs with high-volume sampler. Ac Soxhlet extraction	TA98, TA100, plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Mutagenic potency (per m^3) higher without S9 and elevated in autumn and winter, relative to summer. Maximum potency on TA98 without S9 ~38 rev/m^3; with S9 ~29 rev/m^3	Gilli et al. (2007b)

Supplemental Table S7 (continued)

Geographical location	Test article	*Salmonella* strains[a]/assay version	Results	Reference
Turin, Italy (2007)	PM_{10} and $PM_{2.5}$ from 2 urban sites, collected on GFFs with high-volume sampler. Ac Soxhlet extraction	TA98, TA98NR, YG1021, YG1024, plate incorporation assay, without S9 activation	Mutagenic potency on TA98 (per m^3) higher in autumn and winter; elevated for high-traffic site. Increase in activity on YG1021 and decrease on TA98NR, relative to TA98. Potency of $PM_{2.5}$ higher than that of PM_{10}. Maximum potency on TA98 without S9 ~113 rev/m^3	Traversi et al. (2011)
Padana Plain, Italy (2006)	$PM_{2.5}$ from high-traffic locations in 3 cities, collected on Teflon filters with high-volume sampler. Ac Soxhlet extraction	TA98, TA98NR, YG1021, plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Mutagenic potency (per m^3) higher without S9. No appreciable difference between locations. Without S9, substantial reduction in activity on TA98NR, relative to TA98; substantial increase in activity on YG1021, relative to TA98. Maximum potency on TA98 without S9 ~35 rev/m^3; with S9 ~20 rev/m^3	Traversi et al. (2009)
Padana Plain, Italy (1994–1995)	$PM_{2.5}$ from high-traffic locations in Bologna, collected with cascade impactor. Sequential Soxhlet extraction with Ac and DCM	TA98, TA100, plate incorporation assay, with and without PB/5,6-BF-induced rat liver S9	Mutagenic potency (per m^3) higher with S9; highest potency (per m^3 or per mg of PM) for smallest size fraction (< 0.4 µm). Maximum potency on TA98 without S9 ~17 rev/m^3; with S9 ~36 rev/m^3	Pagano et al. (1996)
Padana Plain, Italy (2005–2006)	$PM_{2.5}$ from high-traffic locations in 3 cities, collected on Teflon filters with high-volume sampler. Ac Soxhlet extraction	TA98, TA100, plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Mutagenic potency (per m^3) higher without S9, and substantially elevated in autumn and winter. No appreciable difference between locations. Maximum potency on TA98 without S9 ~50 rev/m^3; with S9 ~38 rev/m^3	Traversi et al. (2008)
Po Valley, Italy (1990–1994)	Airborne PM from residential/commercial locations in Parma, collected on GFFs with low-volume sampler. Tl or Ac Soxhlet extraction	TA98, TA100, standard plate incorporation assay, with and without PB/5,6-BF-induced rat liver S9	48 pooled monthly samples analysed; almost all elicited positive response. Similar responses with and without S9 for 3 of 4 years; without S9 exceeded with S9 in final year. Responses frequently elevated in autumn and/or winter months. Elevated airborne PAHs in autumn and winter months	Rossi et al. (1995)
Po Valley, Italy (1990)	Airborne PM from residential/commercial locations in Parma, collected on GFFs with low-volume sampler. Tl Soxhlet extraction	TA98, TA100, standard plate incorporation assay, with and without rat liver S9	9 pooled monthly samples; significant mutagenicity for most sampling periods. Responses elevated on TA98 and generally higher for autumn and spring, relative to summer. Similar responses with and without S9, but somewhat elevated with S9 for autumn. Mutagenicity positively correlated with atmospheric CO and NO_x, and negatively correlated with temperature. Maximum potency on TA98 without S9 ~150 rev/m^3; with S9 ~110 rev/m^3	Poli et al. (1992)
Po Valley, Italy (1991–1998)	Airborne PM from residential/commercial locations in Parma, collected on GFFs with low-volume sampler. Tl Soxhlet extraction	TA98, TA100, standard plate incorporation assay, with and without rat liver S9	96 pooled monthly samples analysed. Continuous evidence of mutagenic activity, with evidence of temporal decline in mutagenic potency (per m^3 equiv) from 1991 to 1998. Earliest samples showed enhanced potency without S9. Highest potency in autumn and winter months. Maximum potency on TA98 without S9 ~130 rev/m^3; with S9 ~150 rev/m^3	Poli et al. (1999)

Supplemental Table S7 (continued)

Geographical location	Test article	*Salmonella* strains[a]/assay version	Results	Reference
Po Valley, Italy (1996, 1997)	Airborne PM from residential/commercial locations in Parma, collected on GFFs with low-volume sampler. Tl or Ac Soxhlet extraction	TA98, TA100, standard plate incorporation assay, with and without rat liver S9	4 pooled monthly samples analysed; late autumn and late winter samples generally more potent (per m^3 equiv). Ac and Tl extracts showed similar potency, except for TA98 with S9, where Ac extract 2-fold more potent. Similar potency with and without S9, except for TA100, which showed enhanced potency with S9. Maximum potency on TA98 without S9 ~35 rev/m^3; with S9 ~40 rev/m^3	Buschini et al. (2001)
Genoa, Italy (1986–1987)	Airborne PM from 10 sites with low, moderate, or high traffic, collected on GFFs with high-volume sampler. CX sonication extraction, TLC fractionation	TA1535, TA98, TA100, TA102, TA104, TA97, TA98NR, TA98/1,8-DNP_6, standard plate incorporation assay, with and without rat liver S9	Mutagenic potency (per µg of EOM) of crude extracts high on TA98 with S9. High frequency of positive responses for TA100 with S9 and TA98 without S9. Marked reduction of some samples on NR- and OAT-deficient strains. Some evidence of seasonal variation, with low activity in summer. TA100 activity with S9 significantly correlated with PAH levels	De Flora et al. (1989)
Emilia-Romagna region, Italy (1999–2000)	TSP, PM_{10}, and $PM_{2.5}$ from urban and rural areas, collected on GFFs with low-volume sampler. Tl or Ac Soxhlet extraction	TA98, TA100, standard plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Higher mutagenic potency (per m^3) during winter months. Potency frequently similar or higher with S9, except for high-traffic locations, where potency reduced with S9. Potency (per µg of PM) increased with decreasing PM size. Maximum potency on TA98 ~500 rev/m^3 without S9; ~380 rev/m^3 with S9	Cassoni et al. (2004)
Emilia-Romagna region, Italy (2000–2002)	$PM_{2.5}$ from urban and rural areas, collected on quartz filters with low-volume sampler. Ac Soxhlet extraction	TA98, TA100, standard plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Mutagenic potency (per m^3) showed clear increase in autumn and winter months; generally higher without S9. Substantial variability in mutagenic potency across sites with similar population and traffic density. Local agreement between mutagenic potency and levels of CO and NO_2. Maximum potency on TA98 ~100 rev/m^3 without S9; ~90 rev/m^3 with S9	Cassoni et al. (2004)
Padua, Italy (1990–1991)	Airborne PM from 8 high-traffic locations, collected on GFFs with high-volume sampler. Sequential Soxhlet extraction with DCM and MeOH	TA98, TA100, TA98NR, TA100NR, standard plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Mutagenic potency (per m^3 or per mg of PM) higher with S9, and elevated in winter compared with summer. Decrease in activity on NR-deficient strains relative to parent strains. Maximum potency on TA98 ~51 rev/m^3 without S9; ~98 rev/m^3 with S9	Nardini & Clonfero (1992)
Ispra, Italy (1980–1981)	Airborne PM from rural location, collected with high-volume sampler. Sequential DCM, MeOH extraction, DMSO shaker extraction	TA98, TA1537, TA100, standard plate incorporation assay, with and without PB-5,6-BF-induced rat liver S9	Mutagenic potency (per mg of PM) elevated with S9 and markedly higher in winter, especially for TA1537 and TA100. Maximum potency on TA98 ~10 rev/m^3 without S9; ~10 rev/m^3 with S9. Mutagenicity on TA98 with S9 highest for organic base fraction, followed by polar neutrals	Reali et al. (1984)

Supplemental Table S7 (continued)

Geographical location	Test article	*Salmonella* strains[a]/assay version	Results	Reference
Rome, Italy (1986)	Airborne PM collected on GFFs with high-volume sampler. DCM Soxhlet extraction, acid–base–neutral fractionation	TA98, TA98NR, TA98/1,8-DNP_6, standard plate incorporation assay, with and without rat liver S9	Potency (per m^3 equiv) similar with and without S9, and substantially higher in winter. Relatively little reduction on TA98NR relative to TA98; substantial reductions on TA98/1,8-DNP_6. Neutral and basic fractions elicited strongest responses, enhanced with S9, particularly for winter sample. Maximum potency on TA98 ~18 rev/m^3 without S9; ~17 rev/m^3 with S9	Crebelli (1989)
Rome, Italy (1988)	Airborne PM from heavy-traffic site, collected on GFFs with high-volume sampler. DCM Soxhlet extraction, acid–base–neutral fractionation	TA97a, TA98, TA100, TA102, TA100NR, TA98NR, TA98/1,8-DNP_6, *E. coli* WP2, standard plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Mutagenic potency (per mg of EOM) highest on TA98 with S9, followed by TA97a. Low response on TA102. High potency on TA98 (per mg of EOM) without S9 for acidic fraction; neutral fraction similar with and without S9; basic fraction higher with S9	Crebelli et al. (1991)
Rome, Italy (1990–1991)	PM_{10} from heavy-traffic location, collected on GFFs with high-volume sampler. DCM Soxhlet extraction	TA98, microsuspension assay, with and without Aroclor 1254-induced rat liver S9	Mutagenic potency (per m^3) higher without S9, highest in winter months and lowest in spring. Maximum potency without S9 ~32 rev/m^3; with S9 ~10 rev/m^3. Microsuspension potency 2–5-fold higher than for plate incorporation. Potency negatively correlated with temperature	Crebelli et al. (1995)
Rome, Italy (1992–1993)	PM_{10} from heavy-traffic site, collected on GFFs with high-volume sampler. DCM Soxhlet extraction	TA98, plate incorporation assay, without S9 activation	Mutagenic potency (per m^3) modestly increased in autumn and winter collection periods. Maximum mutagenic potency ~6 rev/m^3. Weak association between mutagenic activity and VOC concentration	Fuselli et al. (1995)
Sicily, Italy (1993)	Airborne PM from urban and rural locations, collected on GFFs with high-volume sampler. CX Soxhlet extraction	TA97a, TA98, TA100, YG1021, YG1026, YG1024, YG1029, standard plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Substantial increases in potency (per m^3 equiv) for urban area, relative to rural. Substantial increase in potency on YG1024 with S9, relative to TA98. PAH concentrations far higher in urban area (e.g. 5–25-fold). Maximum potency on TA98 with S9 ~28 rev/m^3	Izzotti et al. (1996)
Athens, Greece (1983)	Monthly PM samples, collected on cellulose filters with high-volume sampler. Hx sonication extraction	TA98, standard plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	All 19 samples showed significant positive responses, with little difference between with and without S9. Little seasonal variability. Maximum potency without S9 (per m^3 equiv) ~72.8	Athanasiou et al. (1987)
Athens, Greece (1984)	TSP from 4 urban sites and 1 rural site, collected on GFFs with cascade impactor. BZ Soxhlet extraction	TA98, standard plate incorporation assay, without S9	Highest potency (per m^3) for high-traffic city centre site; lowest for light-traffic industrial area. Correlation between potency and PAH levels. Maximum potency ~4 rev/m^3	Athanasiou et al. (1986)

Supplemental Table S7 (continued)

Geographical location	Test article	*Salmonella* strains[a]/assay version	Results	Reference
Athens, Greece (1984)	TSP from 4 urban sites and 1 rural site, collected on GFFs with cascade impactor. Soxhlet extraction with BZ or CX	TA98, standard plate incorporation assay, without S9	Highest potency (per m^3) for city centre locations, and increase in winter relative to summer. Correlation between mutagenic potency without S9 and B[*a*]P concentration. Maximum potency ~35 rev/m^3. Largest fraction of mutagenic activity associated with PM < 1.1 µm. Reduced potency (per m^3) at increased sampling heights	Viras et al. (1990)
Paris, France (1979–1980)	Airborne PM from 2 urban sites, collected on GFFs or Teflon filters. Sequential extractions with Chl and Ac, with agitation, or Chl extraction with agitation and sonication	TA1535, TA1537, TA1538, TA98, TA100, plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Highest potency (per m^3) on frameshift strains without S9. Maximum potency on TA98 without S9 ~190 rev/m^3; with S9 ~40 rev/m^3	Courtois et al. (1981)
Paris, France (1983–1985)	Airborne PM from an urban site, collected on GFFs with high-volume sampler. DCM or Ac sonication extraction	TA1538, TA98, TA1537, TA97, TA1535, TA100, TA102, TA98NR, plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Mutagenic potency (per µg of EOM) on TA98 and TA100 increased with S9 for winter samples; S9 effect much lower or negligible for spring samples. Decrease in activity on TA98NR, relative to TA98. Maximum potency on TA98 without S9 ~60 rev/m^3; with S9 ~100 rev/m^3	Courtois et al. (1988)
Paris, France (1980–1981)	Size-fractionated PM from central Paris, collected with cascade impactor. ACN extraction	TA98, TA98NR, plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Highest potency (per mg of PM) on with S9, and increase in activity with decreasing PM size; maximum potency for PM < 1.1 µm. 75% of activity associated with PM < 1.1 µm, 90% with PM < 2 µm. Strong decrease in mutagenicity of TA98NR, relative to TA98	Festy et al. (1984)
Paris region, France (1978–1979)	Airborne PM from 5 sites in city centre and suburbs, collected on Teflon filters. Agitation and sonication with Chl, or sequential extraction with Chl and Ac	TA98, TA100, plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Highest potency (per mg of PM) without S9, and substantial elevations in winter months. Close correspondence between mutagenic potency and PAH concentration	Festy (1980)
Dunkirk, France	Airborne PM, collected with cascade impactor. Organic fraction thermally desorbed	TA98, YG1041, plate incorporation assay, with and without Aroclor 1254-induced rat liver S9, suspensions of PM or thermally desorbed PM in DMSO	No significant responses on TA98. Significant positive response to a single concentration of $PM_{2.5}$ on YG1041; higher activity without S9	André et al. (2011)

Supplemental Table S7 (continued)

Geographical location	Test article	*Salmonella* strains[a]/assay version	Results	Reference
Barcelona, Spain (1989–1990)	Airborne PM from 2 urban locations, collected on GFFs with high-volume sampler. DCM sonication extraction, fraction by GPC	TA98, standard plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Mutagenic potency (per m^3) 13–32% higher with S9; similar potency for PM from 2 locations. Maximum potency with S9 ~100 rev/m^3; without S9 ~78 rev/m^3. Potency without S9 corresponds with levels of nitroarenes; activity with S9 corresponds with levels of aromatic ketones and quinones. Seasonal variation in ketones, quinones, and lactones indicate strong contribution of atmospheric transformation processes	Bayona et al. (1994)
Barcelona, Spain (1990)	Airborne PM from urban locations, collected on GFFs with high-volume sampler. DCM sonication extraction, fraction by GPC and subfractionation	TA98, TA98NR, TA98/1,8-DNP_6, standard plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Mutagenic potency higher without S9. Several potent fractions reduced on TA98NR and TA98/1,8-DNP_6, relative to TA98. Active fractions contain PAHs, nitro-PAHs, aromatic ketones and quinones, and N-heterocyclics. Maximum potency with S9 ~45 rev/m^3; without S9 ~100 rev/m^3	Casellas et al. (1995)
Caserta, Italy	Atmospheric contamination at 5 locations in Caserta affected by different levels of vehicle traffic, in situ 3 wk deployments of semipermeable membrane devices	Reverse mutation of dark mutants of *Vibrio fischeri*, with and without rat liver S9 (Mutatox test)	Significant positive response with S9 for all sites examined; 3 of 5 positive without S9. No quantitative analyses	Isidori et al. (2003)

[a] YG1021: TA98 with plasmid pYG216, NR-overproducing strain; YG1024: TA98 with plasmid pYG219, OAT-overproducing strain; YG1041: TA98 with plasmid pYG233, NR- and OAT-overproducing strain; YG1026: TA100 with plasmid pYG216, NR-overproducing strain; YG1029: TA100 with plasmid pYG219, OAT-overproducing strain; YG1042: TA100 with plasmid pYG233, NR- and OAT-overproducing strain.

Ac, acetone; ASE, accelerated solvent extraction; 5,6-BF, 5,6-benzoflavone; B[*a*]P, benzo[*a*]pyrene; BZ, benzene; Chl, chlorophyll; CO, carbon monoxide; CX, cyclohexane; DCM, dichloromethane; DEE, diethyl ether; DMSO, dimethyl sulfoxide; EOM, extractable organic matter; equiv, equivalent; GFFs, glass-fibre filters; GPC, gel permeation chromatography; Hx, hexane; MeOH, methanol; NMHC, non-methane hydrocarbons; NO, nitrogen oxide; NO_2, nitrogen dioxide; NR, nitroreductase; OAT, *O*-acetyltransferase; PAHs, polycyclic aromatic hydrocarbons; PB, phenobarbital; PCB, polychlorinated biphenyl; PM, particulate matter; PM_{10}, particulate matter with particles of aerodynamic diameter < 10 µm; $PM_{2.5}$, particulate matter with particles of aerodynamic diameter < 2.5 µm; PUF, polyurethane foam; rev, revertants; SO_2, sulfur dioxide; SVOCs, semivolatile organic compounds; THF, tetrahydrofuran; Tl, toluene; TLC, thin-layer chromatography; TSP, total suspended particles; VOCs, volatile organic compounds; wk, week or weeks.

Supplemental Table S8 Summary of studies that used bacterial mutagenicity assays (e.g. Ames assay) to assess the ability of outdoor air to induce genetic mutations – Asia

Geographical location	Test article	*Salmonella* strains[a]/assay version	Results	Reference
Mumbai, India	Airborne PM (> 0.8 µm) collected on GFFs. DMSO or water extraction using mortar and pestle	TA1537, TA1535, TA1538, TA100, TA98, standard plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Only TA100 results recorded. Highest potency (per µL of extract) for DMSO extracts with S9. Highest response for site with high population density, traffic, and industrialization	Shenoy & Chaubal (1984)
Agra, India (2010)	PM_{10} and $PM_{2.5}$ from a single site, collected on GFFs. DCM sonication extraction	TA98, TA100, plate incorporation assay, without rat liver S9	Weak responses with modest increase for $PM_{2.5}$ relative to PM_{10}	Singla et al. (2012)
Tokyo, Japan (1988, 1990)	Airborne PM from an urban site during winter, collected on GFFs with high-volume sampler. DCM sonication extraction	TA98, TA100, YG1024, YG1029, pre-incubation assay and Spiral assay, without S9 activation	Mutagenic activity higher with Spiral assay; enhanced on YG1024 and YG1029 compared with parent strains. Maximum potency on TA98 ~450 rev/m^3 for Spiral and 318 rev/m^3 for pre-incubation	Houk et al. (1992)
Tokyo, Japan (1980–1981)	Airborne PM, collected on GFFs with high-volume sampler. BZ:EtOH (4:1) sonication extraction, acid–base–neutral fractionation	TA98, TA100, pre-incubation assay, with and without PCB-induced rat liver S9	Mutagenic potency (per mg of EOM or m^3) on TA98 and TA100 higher with S9; highest activity for neutral fraction. Potency on TA98 without S9 ~11 rev/m^3; with S9 ~12 rev/m^3. Neutral fraction induced tumours in ICR mice	Sasaki et al. (1987)
Tokyo, Japan (1983)	Airborne PM_{10}, collected on GFFs with high-volume sampler. MeOH extraction and extract fractionation	TA98 pre-incubation assay, with and without PCB-induced rat liver S9	Potency (per µg of EOM) higher without S9 activation. Highest potency for crude MeOH extract and NM fraction	Sakitani & Suzuki (1986)
Tokyo, Japan (1978–1979)	Airborne PM, collected on GFFs with high-volume sampler. NM extraction	TA98, pre-incubation assay, with and without rat liver S9	Mutagenic potency (per m^3) higher with S9; elevated in autumn compared with spring and summer. With S9, daytime higher than night-time, but only for summer and autumn. Maximum potency without S9 ~8 rev/m^3; with S9 ~16 rev/m^3	Sakitani & Hayashi (1986)
Tokyo, Japan	Airborne PM, collected on GFFs with high-volume sampler. MeOH extraction, solvent fractionation	TA98, pre-incubation assay, with and without rat liver S9	Mutagenic potency (per µg of EOM) higher without S9; highest activity in NM fraction, compared with CX. No response for MeOH/water fraction	Sakitani & Suzuki (1986)
Tokyo, Japan (1978–1979)	Airborne PM from city centre, collected on GFFs with high-volume sampler. MeOH extraction	TA98, pre-incubation assay, with PCB-induced rat liver S9	Mutagenic potency (per m^3) frequently higher during the day, especially in autumn. Seasonal average potency higher without S9; progressive potency decline from winter to autumn, to summer and spring. Some correlation between mutagenic activity and B[*a*]P concentration. Maximum potency without S9 ~10 rev/m^3; with S9 ~8 rev/m^3	Shimizu et al. (1983)

Supplemental Table S8 (continued)

Geographical location	Test article	*Salmonella* strains[a]/assay version	Results	Reference
Tokyo, Japan (1978–1979)	Airborne PM from city centre, collected on GFFs with high-volume sampler. NM extraction	TA98, pre-incubation assay, with PCB-induced rat liver S9	Seasonal average mutagenic potency (per m^3) higher with S9 in spring, autumn, and summer; opposite in winter. Daytime potency with S9 higher than night-time in winter, lower in summer. Progressive decline in potency with S9 from winter to autumn, to summer and spring. Some correlation between mutagenic activity and B[*a*]P concentration. Maximum potency without S9 ~18 rev/m^3; with S9 ~18 rev/m^3	Shimizu et al. (1982)
Tokyo, Japan (1980)	Airborne PM from an urban location, collected on GFFs. BZ:EtOH (3:1) sonication extraction	TA98, TA100, pre-incubation assay, with PCB-induced rat liver S9	Mutagenic potency (per m^3) higher without S9, and higher in colder months (January and October) compared with April and July. Analysis of daily values showed > 10-fold variation from lowest to highest within a given month. Significant correlations between mutagenic activity and PAH levels. Maximum potency on TA98 without S9 ~58 rev/m^3; with S9 ~47 rev/m^3	Goto et al. (1982)
Tokyo, Japan (1983–1984)	Airborne PM from urban locations, collected on GFFs. Sonication extraction	TA98, TA100, pre-incubation assay, with PCB-induced rat liver S9	Mutagenic potency (per m^3) frequently higher with S9. At one location, values for winter and autumn exceeded those for spring and summer. At second location, autumn and spring values greater than winter values. Variation attributed to seasonal wind direction. Maximum potency on TA98 without S9 ~70 rev/m^3; with S9 ~52 rev/m^3	Ohtani et al. (1985)
Tokyo area, Japan (2005)	Size-fractionated PM samples from Saitama City, collected with cascade impactor. DCM sonication extraction	TA98, YG1024, pre-incubation assay, with and without rat liver S9	Mutagenic potency without S9 (per mg of PM) increased with decreasing PM size; highest potency for PM < 0.1 µm. Potency (per m^3) highest for size fractions of 0.1–1.0 µm. Activity enhanced ~10-fold on YG1024 relative to TA98. Five nitro-PAHs accounted for 14–24% of activity of ultrafine PM without S9; ~90% of mutagenic activity associated with PM < 2.1 µm. Potency (per mg of PM) increased with decreasing PM size. Maximum potency on TA98 without S9 ~13 rev/m^3	Kawanaka et al. (2006, 2008)

Supplemental Table S8 (continued)

Geographical location	Test article	*Salmonella* strains[a]/assay version	Results	Reference
Tokyo area, Japan (2003)	Size-fractionated PM samples from Saitama City, collected with cascade impactor. DCM sonication extraction	TA98, YG1024, pre-incubation assay, with and without rat liver S9	Mutagenic potency (per m^3) higher without S9, and maximum potency corresponded to PM sizes of 0.68–1.2 µm. Potency significantly increased on YG1024 relative to TA98. Similar peak for PAH concentrations (pg per m^3). Approximately 90% of the mutagenic activity associated with PM < 2.1 µm. Potency (per mg of PM) increased with decreasing PM size. Maximum potency on TA98 without S9 ~18 rev/m^3; with S9 ~14 rev/m^3	Kawanaka et al. (2004)
Tokyo area, Japan (2005)	Size-fractionated PM samples from Saitama City, collected with cascade impactor. DCM sonication extraction	TA98, YG1024, pre-incubation assay, with and without rat liver S9	Similar mutagenic potency (per m^3) with and without S9; similar results for roadside and suburban locations with marginal increase at roadside location. Maximum potency for particles between 0.3 µm and 1.2 µm. Potency (per mg of PM) increased with decreasing PM size. Although ultrafine PM made small contributions to PM mass, it accounted for 11–30% of the mutagenic activity that would be expected to be deposited in alveolar regions. Maximum potency on TA98 without S9 ~10 rev/m^3; with S9 ~10 rev/m^3	Kawanaka et al. (2011)
Tokyo area, Japan (2001)	Size-fractionated PM samples from Minato-ku, collected with cascade impactor. DCM sonication extraction	YG1024, microsuspension assay, with and without rat liver S9	Mutagenic potency (per m^3) higher without S9 and maximum potency corresponds to PM sizes of 0.33–1.25 µm. Potency (per mg of PM) increased with decreasing PM size; maximum associated with ultrafine PM < 0.22 µm. Potency higher without S9	Endo et al. (2003)
Tokyo area, Japan (1989–1990)	Size-fractionated PM samples from Setagaya and Itabashi, collected with cascade impactor. Organic extraction	TA98, microsuspension assay, with and without rat liver S9	Mutagenic potency (per m^3) elevated for smaller PM sizes (< 1 µM). Potency positively correlated with levels of BkF. Dramatic increase in mutagenic potency (per µg of PM) with decreasing PM size. Total potency on TA98 > 500 rev/m^3. Potency much higher in winter	Matsumoto et al. (1993)
Tokyo and Okayama, Japan (1991–1992)	Airborne PM from urban locations, collected on quartz filters with high-volume sampler. MeOH sonication extraction, blue cotton purification	TA98, pre-incubation assay, with and without PCB-induced rat liver S9	Potency (per m^3) elevated with S9 for autumn and winter. Some indication of general elevation in potency for autumn and winter compared with summer. Blue cotton extracts generally more potent without S9. Maximum potency for Okayama ~16 rev/m^3 without S9; ~23 rev/m^3 with S9; for Tokyo ~26 rev/m^3 without S9; ~30 rev/m^3 with S9. Potency of blue cotton extracts almost always lower than that of crude extract	Iwado et al. (1994)

Supplemental Table S8 (continued)

Geographical location	Test article	*Salmonella* strains[a]/assay version	Results	Reference
Izu and Kawasaki, Japan (1979)	Airborne PM from 2 locations, collected on GFFs with vacuum sampler. Sequential Soxhlet extraction with MeOH and CX	TA98, TA100, plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Higher mutagenic activity (per mg of PM) without S9; elevated at high-traffic site. Maximum potency on TA98 with S9 ~13 rev/m^3	Sutou et al. (1980)
Ōhmuta and Fukuoka, Japan (1974–1980)	Airborne PM samples from 6 industrial and residential locations, collected on GFFs with high-volume sampler. MeOH Soxhlet extraction	TA1535, TA1536, TA1537, TA1538, TA98, TA100, plate incorporation assay, with Aroclor 1254-induced rat liver S9	Mutagenic potency (per m^3) with S9 activation higher for industrial locations, compared with residential sites. Strongest response on TA98. Maximum potency on TA98 with S9 ~445 rev/m^3	Tokiwa et al. (1977)
Ōhmuta and Fukuoka, Japan (1977–1978)	Airborne PM samples from 24 industrial and residential locations, collected on GFFs with high-volume sampler or cascade impactor. MeOH or BZ Soxhlet extraction, detailed fractionation	TA98, TA100, plate incorporation assay, with Aroclor 1254-induced rat liver S9 or rat lung S9	Mutagenic potency (per m^3) at industrial site higher on TA98 compared with TA100; opposite for heavy-traffic site. Maximum potency on TA98 with S9 ~73 rev/m^3. Fractionation showed highest S9-activated potency for neutrals and acidic compounds. Collection of a large PM sample from a heavily polluted site yielded potency on TA98 with S9 ~444 rev/m^3. Highest activity in the 0.3–1.0 µm fraction (38% of total)	Tokiwa et al. (1980)
Ōhmuta and Fukuoka, Japan (1974–1980)	Airborne PM samples from several locations, collected on GFFs with high-volume sampler. MeOH Soxhlet extraction	TA98, TA100, plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Mutagenic potency (per m^3) frequently elevated with S9. Samples divided into 5 "pollution level" groups based on mutagenic potency on TA98 with S9; minimum of < 2.3 rev/m^3 to maximum of > 116 rev/m^3. Maximum potency ~200 rev/m^3. Samples from sites with low levels of NO, NO_2, and SO_2 showed lowest mutagenic activity	Tokiwa et al. (1983)
Fukuoka, Japan	Airborne PM and SVOCs, collected on Teflon-coated filters and XAD-4 resin with high-volume sampler. DCM sonication extraction, detailed fractionation	TA98, plate incorporation assay, without S9 activation	Basic and neutral fractions of SVOCs accounted for 59% and 20%, respectively, of activity without S9. Detected several previously unknown nitro-azabenzo[*a*]pyrene derivatives	Sera et al. (1994)
Osaka, Japan (1983–1984)	Airborne PM, collected on GFFs with high-volume sampler. BZ:EtOH (3:1) sonication extraction, acid–base–neutral fractionation, HPLC fractionation	TA98, TA100, pre-incubation assay, with and without Aroclor 1254-induced rat liver S9	Higher mutagenic potency (per µg of EOM) with S9; except for subfractions of the neutral fraction. Highest mutagenic activity in moderately polar fraction. High activity in subfractions containing ketones, azarenes, quinones, and PAHs	Matsumoto & Inoue (1987)
Osaka, Japan (1998)	Airborne PM from a suburban site, collected on quartz filters. BZ:EtOH (3:1) sonication extraction	YG1024, pre-incubation assay, with and without rat liver S9	Diurnal variation in potency (per m^3) that followed temporal patterns of NO, CO, and 1-nitropyrene (i.e. high in early morning and late evening). Despite strong correlations, nitroarene concentrations estimated to account for a maximum of 1% of mutagenic activity	Kameda et al. (2004)

Supplemental Table S8 (continued)

Geographical location	Test article	*Salmonella* strains[a]/assay version	Results	Reference
Several cities, Japan (1986, 1987, 1988)	Airborne PM samples from 6 urban and 2 rural locations, collected on GFFs with high-volume sampler. Sonication or Soxhlet extraction with BZ:EtOH (3:1), Tl:EtOH (3:1), or DCM	TA98, TA100, microsuspension and plate incorporation assays, with and without PCB- or PB/5,6-BF-induced rat liver S9	Mutagenic potency (per mg of EOM) higher with S9. Similar results for Aroclor- and PB/5,6-BF-induced S9. Similar results for plate incorporation and microsuspension versions of the assay	Matsushita et al. (1992)
Several cities, Japan (1985, 1988, 1990)	Airborne PM from 5 urban and suburban locations, collected on quartz filters with high-volume sampler. MeOH sonication extraction, blue cotton purification	TA98, TA100, TA98/1,8-DNP_6, plate incorporation assay, with and without PCB-induced rat liver S9	Mutagenic activity (per m^3) generally higher with S9, and response for blue cotton extracts enhanced relative to crude extract. Responses reduced on TA98/1,8-DNP_6, relative to parent strain	Iwado et al. (1991)
Kawasaki and Sagamiko, Japan (1985, 1988, 1990)	Airborne PM from several urban/industrial and non-urban locations, collected on GFFs with high-volume sampler. BZ Soxhlet extraction, transfer to FBS	TA98, TA100, pre-incubation assay, with and without rat liver S9	Mutagenic potency (per m^3) higher with S9; higher for urban sites. Benzene extract more potent than serum extract. Maximum potency on TA98 with S9 ~19 rev/m^3; with S9 ~7 rev/m^3	Ohsawa et al. (1983)
Sagamihara, Japan (1984–1985)	Airborne PM collected on quartz filters with high-volume sampler. BZ:EtOH (3:1) sonication extraction	TA98, TA100, TA98NR, plate incorporation assay, with and without PCB-induced rat liver S9	Mutagenic potency (per m^3) higher without S9, and elevated in winter compared with summer or spring. Large daily potency variations (i.e. up to 10-fold); low values on Sundays and holidays. Strong potency (per µg of EOM) reductions on TA98NR relative to TA98. Maximum potency on TA98 with S9 ~52 rev/m^3; with S9 ~43 rev/m^3	Takagi et al. (1992)
Kobe, Japan (1975)	Airborne PM collected on GFFs with high-volume sampler. BZ Soxhlet extraction	TA1535, TA1537, TA1538, TA1536, TA98, TA100, with and without PB-induced rat liver S9	Mutagenic potency (per µg of EOM) increased with S9; strong response on TA98. Substantial fraction of activity accounted for by acidic (16%) and neutral (30%) fractions. Strong response from neutral subfractions containing PACs such as oxygenated aromatics	Teranishi et al. (1978)
Kobe, Japan	Airborne PM collected on GFFs with high-volume sampler. BZ:MeOH (4:1) Soxhlet extraction; extract transferred to FBS, saline, or DMSO	TA98, plate incorporation assay, with and without PB/DBA-induced rat liver S9	Mutagenic activity with S9 for serum solution ~60% of DMSO. Without S9, activity of DMSO and serum solutions about equal	Takeda et al. (1983)
Kobe, Japan (1983)	Airborne PM collected on GFFs with high-volume sampler. BZ:EtOH (3:1) sonication extraction	TA98, plate incorporation assay, with and without with and without PB-induced rat liver S9	Mutagenic potency (per mg of PM) elevated with S9	Takeda & Teranishi (1986)

Supplemental Table S8 (continued)

Geographical location	Test article	*Salmonella* strains[a]/assay version	Results	Reference
Kobe, Japan (1992)	Airborne PM from high-traffic site, collected on GFFs with high-volume sampler. BZ:EtOH (3:1) sonication extraction, blue rayon fractions	TA98, TA100, YG1021, YG1024, TA98NR, TA98/1,8-DNP_6, with and without PB-induced rat liver S9	Mutagenic potency (per m^3) on TA98 increased with S9; elevated in autumn. Reductions in potency on TA98NR and TA98/1,8-DNP_6, relative to TA98; dramatic increases in potency on YG1021 (3–4-fold) and YG1024 (5–10-fold). Positive correlation between potency and NO_2; negative correlation with temperature. Maximum potency on TA98 without S9 ~26 rev/m^3; with S9 ~52 rev/m^3	Yamaguchi et al. (1994)
Hyōgo Prefecture, Japan (1978)	TSP collected at 2 urban/industrial sites and 1 rural site, collected on GFFs. BZ Soxhlet extraction	TA98, plate incorporation assay, with and without PB/DBA-induced rat liver S9	Mutagenic potency (per m^3) elevated with S9 for industrial area only; potency at industrial site higher than at residential and rural site (lowest). Maximum potency on TA98 without S9 ~14 rev/m^3; with S9 ~20 rev/m^3	Takeda et al. (1984)
Kanazawa, Japan (1993)	Airborne PM from downtown area, collected with cascade impactor. BZ:EtOH (3:1) sonication extraction	TA98, YG1024, without S9 activation	Mutagenic potency (per m^3) increased with decreasing PM size; maximum for fraction < 1.1 µm. Noteworthy contributions from DNPs (< 2%); source of most of mutagenicity unknown. Total mutagenic potency of 5 size fractions ~15 rev/m^3	Hayakawa et al. (1995)
Sapporo, Japan (1974–1992)	Airborne PM from residential area, collected on GFFs with high-volume sampler. DCM sonication extraction	TA98, TA100, pre-incubation assay, with and without Aroclor 1254-induced rat liver S9	Strong seasonal trend in mutagenic potency (per m^3), with peak in winter and trough in summer. Temporal decline in potency with S9 from 1974 to 1992; no such trend without S9. B[*a*]P showed similar temporal decline. Maximum potency on TA98 without S9 ~35 rev/m^3 (1986); with S9 ~40 rev/m^3 (1974)	Matsumoto et al. (1998)
Yahata, Japan (Kyushu, 1980–1983)	Airborne PM from suburban area, collected on GFFs or quartz filters with high-volume sampler. Organic extraction	TA98, with and without PCB-induced rat liver S9	Mutagenic potency (per m^3) generally higher with S9, particularly in colder months (September to March). Potency values quite variable, with a tendency to higher levels in colder months (i.e. winter). Maximum potency on TA98 without S9 ~7.5 rev/m^3; with S9 ~12 rev/m^3. Positive association between mutagenicity and both atmospheric PAHs and heavy metals	Kodama et al. (1983)
Chiba, Japan (1979–1980)	Airborne PM from residential area, collected on GFFs with high-volume sampler. BZ Soxhlet extraction	TA98, pre-incubation assay, with and without Aroclor 1254-induced rat liver S9	Mutagenic potency (per µg of EOM) higher with S9. Higher potency (per m^3) in winter. Maximum potency on TA98 without S9 ~17 rev/m^3. Activity without S9 correlated with atmospheric B[*a*]P and NO_x	Fukino et al. (1982)
Tokyo, Japan (1996, 1997)	PM_{10} collected from several urban, residential, and industrial sites, collected on quartz filters with high-volume sampler. DCM sonication extraction	TA98, TA100, pre-incubation assay, with and without rat liver S9	Mutagenic potency (per m^3) frequently higher without S9. Potency on TA98 without S9 ~67 rev/m^3; with S9 ~33 rev/m^3. Strong correlation between activity on TA98 with S9 and PAH concentration	Koyano et al. (2002)

Supplemental Table S8 (continued)

Geographical location	Test article	*Salmonella* strains[a]/assay version	Results	Reference
Taiwan, China (1987–1989)	Airborne PM from 8 urban and suburban locations, collected on GFFs with high-volume sampler. Ac shaker extraction, fraction by size exclusion	TA98, plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Potency (per mg of PM) similar for urban and suburban areas, and potency of all samples increased with S9. Concentration of B[*a*]P not correlated with mutagenic activity. DNPs suspected as significant contributors to outdoor air mutagenicity	Chou & Lee (1990)
Taiwan, China (1989)	Airborne PM, collected on GFFs with high-volume sampler. DCM or Ac shaker extraction, fraction by size exclusion	TA98, TA98NR, plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Mutagenic potency (per mg of PM) higher for Ac extract; higher with S9. Marked reduction in potency on NR-deficient strain. PAHs and nitro-PAHs detected only in Ac extract	Lee et al. (1991)
Taiwan, China (1990–1991)	Airborne PM from 12 urban and suburban locations, collected on GFFs with high-volume sampler. Ac shaker extraction, fraction by size exclusion	TA98, plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Mutagenic potency (per m^3) higher with S9. Potency higher in autumn (dry season) and substantially reduced during heavy rainfall period. Low wind speed contributed to higher potency. Maximum potency on TA98 without S9 ~13 rev/m^3; with S9 ~26 rev/m^3. Nitroarene levels corresponded with mutagenic activity, and PAH profile indicated important contributions from mobile sources	Lee et al. (1994)
Taiwan, China (1993–1994)	TSP and SVOCs from sites near a petrochemical complex, collected on GFFs and PUFs. Hx:Ac:DCM (50:25:25) Soxhlet extraction	TA98, TA100, plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Mutagenic potency (per m^3) of TSP and SVOCs elevated with S9; correlated with concentration of PAHs. Maximum potency of TSP on TA98 without S9 ~60 rev/m^3; with S9 ~85 rev/m^3. Maximum potency of SVOCs on TA98 without S9 ~42 rev/m^3; with S9 ~82 rev/m^3	Tsai et al. (1995)
Taiwan, China (1994)	Airborne PM from 7 sites in Taichung City, collected on GFFs with high-volume sampler. Ac shaker extraction	TA98, plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Mutagenic potency (per m^3) higher with S9; variable across seasons. Maximum potency on TA98 without S9 ~41 rev/m^3; with S9 ~50 rev/m^3. Close correspondence between monthly mean mutagenicity and average concentrations of BghiP, an indicator of mobile-source emissions	Kuo et al. (1998)
Taiwan, China (1999)	TSP from site in Taichung City, collected on GFFs. Ac sonication extraction	TA98, TA100, plate incorporation assay, with and without induced rat liver S9	Mutagenic potency (per m^3) higher with S9; higher in winter months. PAH levels also higher in winter months. Maximum potency on TA98 without S9 ~13 rev/m^3; with S9 ~50 rev/m^3	Wu & Fang (2001)
Taiwan, China (1986–1990)	TSP from 9 locations in Taipei area, collected on GFFs with high-volume sampler. DCM Soxhlet extraction, TLC fractionation	TA98, TA100, plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Mutagenic potency (per mg of PM or per m^3) on TA98 with S9 elicited highest response; decreased potency with increase in sampling altitude. Significant increases associated with heavy traffic; decrease in summer. Maximum potency on TA98 with S9 ~24 rev/m^3. Tunnel sample yielded 130 rev/m^3	Wei et al. (1991)

Supplemental Table S8 (continued)

Geographical location	Test article	*Salmonella* strains[a]/assay version	Results	Reference
Shanghai, China (1992–1993)	Airborne PM from 13 urban sites, collected on GFFs with high-volume sampler. DCM sonication extraction, acid–base–neutral fractionation	TA98, TA100, plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	No significant responses on TA100. Mutagenic potency on TA98 generally higher without S9, and substantially increased in winter. Substantial temporal and spatial variation in potency (per m^3). Maximum potency on TA98 without S9 ~20 rev/m^3; with S9 ~25 rev/m^3. With S9, high activity in basic and polar fraction; without S9, high activity in numerous fractions, including acidic, basic, neutral, and aromatic	Zhao et al. (2002)
Shanghai, China	Airborne PM from residential and industrial locations affected by coking facility. NM extraction	TA98, TA100, plate incorporation assay, with and without S9	Mutagenic potency (per m^3) higher without S9; elevated in residential and industrial areas when coke oven in operation (10–23-fold above control site). When coke oven not operating, 3-fold decrease in potency. Maximum potency on TA98 without S9 (factory entrance) ~2600 rev/m^3; with S9 ~2000 rev/m^3	Yu et al. (1989)
Shanghai, China	TSP from 10 representative areas. NM sonication extraction	TA98, TA100, plate incorporation assay, with and without S9	Mutagenic potency (per m^3) higher without S9; similar results for TA98 and TA100. Maximum potency on TA98 without S9 ~260 rev/m^3	Zhu et al. (1991)
Shanghai, China (1988)	TSP from 5 representative areas. NM sonication extraction; extract separated into 5 fractions	TA98, TA100, plate incorporation assay, with and without S9	Mutagenic potency (per m^3) marginally higher without S9. Maximum potency on TA98 without S9 ~205 rev/m^3. One polar fraction accounted for up to 86% of mutagenic activity. PAH-containing fraction accounted for only 2.6–11% of mutagenicity	Zhu et al. (1990)
Shanghai, China	TSP from 13 representative areas. DCM sonication extraction	TA98, TA100, plate incorporation assay, with and without S9	Positive response for all sites, including control (suburban park). Higher response without S9; higher activity at industrial and commercial sites with heavy vehicle traffic	Zhao et al. (1996)
Shanghai, China	TSP from 4 commercial and suburban areas. DCM sonication extraction; extract separated into 5 fractions	TA98, plate incorporation assay, with and without S9	Mutagenic activity generally higher with S9, and higher in winter compared with summer. Strong responses for fractions containing PAHs and polar aromatics	Zhao & Zhu (1997)
Beijing, China (1981)	TSP from 1 commercial site, 2 residential sites, and control site. BZ Soxhlet extraction	TA98, plate incorporation assay, without S9	Mutagenic potency (per m^3) highest at commercial site, followed by residential site. Negative at control. Maximum potency TA98 ~2.3 rev/m^3	Chen et al. (1982)
Beijing, China (1982)	TSP from 1 commercial site, 2 residential sites, and 1 industrial site. BZ Soxhlet extraction	TA97, TA98, plate incorporation assay, with and without S9	Positive responses on both TA98 and TA97. Mutagenic potency of commercial and residential sites higher with S9	Chen et al. (1983)

Supplemental Table S8 (continued)

Geographical location	Test article	*Salmonella* strains[a]/assay version	Results	Reference
Beijing, China (1984)	TSP from downtown and industrial area. BZ:EtOH (3:1) Soxhlet extraction	TA100, TA98, plate incorporation assay, with and without S9	Higher potency (per mg of EOM) in downtown area, relative to site with petrochemical industry. Lower or equivalent potency with S9	Chen et al. (1987)
Beijing, China (1980)	TSP from 7 urban, suburban, and industrial sites. BZ:MeOH (4:1) Soxhlet extraction, fractionation on silica	TA98, plate incorporation assay, with and without S9	Mutagenic potency (per m^3) highest at downtown (urban) site and lowest at suburban site. Higher response with S9. Fractionation showed highest S9-activated response in PAH-containing fractions and highest response without S9 in polar fractions. Maximum potency on TA98 with S9 ~66 rev/m^3	Zhao et al. (1983)
Beijing, China (2005)	PM_{10} and $PM_{2.5}$ from urban/commercial and industrial sites. Chl Soxhlet extraction, fractionation on silica	TA98, plate incorporation assay, with and without S9	Higher mutagenic activity with S9, and higher in industrial area. Winter samples more potent than summer samples for industrial area only	Che et al. (2008)
Several cities in China (1983–1984)	TSP from residential, industrial, and suburban sites in Shenyang, Guangzhou, Xi'an, Beijing, and Shanghai. DCM Soxhlet extraction	TA98, plate incorporation assay, with and without S9	Mutagenic activity higher in winter compared with summer. Potency (per mg of PM) similar across 5 cities. Highest potency (per m^3) in Shenyang in winter. Maximum potency on TA98 ~90 rev/m^3	Li et al. (1985)
Shenyang, China (1990)	TSP from 3 residential, industrial, and commercial sites, plus control. DCM Soxhlet extraction	TA98, TA98NR, TA98/1,8-DNP_6, plate incorporation assay, without S9	Significant mutagenicity at all sites, including control. Reduced responses on enzymatically deficient strains without S9 confirm contributions from nitro-PAHs. Similar potency (per mg of PM) across all sites	Kong et al. (1994)
Shenyang, China (1990)	TSP from 3 residential, industrial, and commercial sites, plus control. DCM Soxhlet extraction	TA98, YG1021, YG1024, plate incorporation assay, without S9	Significant mutagenicity at all sites, including control. Enhanced responses on enzymatically enhanced strains without S9 confirm contributions from nitro-PAHs	Kong et al. (1995)
Shenyang, China (2000–2002)	TSP from 4 urban, industrial, and suburban sites. DCM sonication extraction	TA98, TA100, plate incorporation assay, with and without S9	Positive responses for all sites, and higher mutagenicity with S9. Similar potency (per mg of PM) across sites investigated	Piao et al. (2007)
Guangzhou, China (1991)	TSP. DCM Soxhlet extraction	TA98, plate incorporation assay, without S9	Mutagenic potency (per m^3) higher in February (winter) and lowest in June (summer). Maximum potency on TA98 without S9 ~23 rev/m^3	Qian & Zhang (1997), Qian et al. (1997)
Guangzhou, China (2002)	TSP, collected with cascade impactor. Sonication extraction with DCM	TA98, plate incorporation assay, with and without S9	Mutagenic potency (per mg of PM) increased with decreasing PM size; maximum for PM < 0.5 µm. Higher potency without S9. Potency (per m^3) significantly higher for smaller PM size fraction	Li et al. (2005)

Supplemental Table S8 (continued)

Geographical location	Test article	*Salmonella* strains[a]/assay version	Results	Reference
Lanzhou, China (1982)	TSP from industrial and commercial sites, plus rural control. Soxhlet extraction with BZ and MeOH; extract separated into 5 fractions	TA98, TA100, TA1537, plate incorporation assay, with and without S9	Mutagenicity higher with S9, and highest responses at industrial sites. Significant responses for PAH-containing fraction. Weak response for commercial site; rural site positive in winter only	Tian et al. (1985)
Lanzhou, China (1985)	TSP from urban sites. Soxhlet extraction with BZ and MeOH; extract separated into 5 fractions	TA98, TA100, plate incorporation assay, with and without S9	Mutagenicity much higher at downtown site, relative to suburban site. Highest activity in winter, followed by autumn and spring. Highest mutagenicity with S9 in polar aromatic fraction. Higher response for samples collected at lower elevation	Tian et al. (1992)
Lanzhou, China (1991)	TSP, collected with cascade impactor. Soxhlet extraction with MeOH, Ac, and DCM	TA98, TA100, plate incorporation assay, with and without S9	Mutagenic activity higher without S9, and highest response associated with PM < 1 µm	Yang et al. (1994)
Lanzhou, China	TSP from 5 industrial, urban, and rural sites. DCM Sonication extraction	TA98, TA100, plate incorporation assay, with and without S9	Significant responses for all sites, including suburban control. Higher activity without S9, higher at industrial/commercial sites. Weak response for rural sample	Ding & Wang (1999)
Chongqing, China	TSP from 5 industrial, residential, and rural sites. BZ Soxhlet extraction	TA98, TA100, plate incorporation assay, with and without S9	Mutagenic activity higher with S9. Similar potency (per µg of EOM) for all 3 sites. Potency (per m^3) much higher for industrial area. Maximum potency on TA98 with S9 ~200 rev/m^3; without S9 ~120 rev/m^3	Lu et al. (1989)
Kunming, China (1986)	TSP from 5 urban and industrial sites. Ac Soxhlet extraction	TA100, plate incorporation assay, with and without S9	Significant positive response at some urban/industrial sites; others failed to elicit a positive response	Hu & Yang (1988)
Jinan, China (1983–1984)	TSP from 3 areas. MeOH Soxhlet extraction	TA1538, TA98, TA100, plate incorporation assay, with and without S9	Similar mutagenic potency (per mg of PM) across 3 sites. Highest mutagenic potency (per m^3) at industrial sites; winter higher than summer	Li et al. (1987)
Harbin, China (1981)	TSP from urban and suburban residential sites. MeOH Soxhlet extraction, solvent fractionation	TA98, TA100, plate incorporation assay, with and without S9	Higher mutagenic activity at urban sites. Maximum potency on TA98 without S9 ~20 rev/m^3	Wang & Zhang (1984)
Daqing, China	TSP from 4 urban, commercial, and industrial sites, plus rural control. MeOH Soxhlet extraction	TA1538, TA98, TA100, plate incorporation assay, with and without S9	Highest mutagenic activity at commercial and industrial sites. Potency (per m^3) approximately 2-fold higher during colder season	Zhang et al. (1991), Wang et al. (1993)
Baotou, China (2004)	$PM_{2.5}$ from an unpolluted site during sandstorm. Sonication extraction with water or DCM, also particle suspensions	TA98, TA100, plate incorporation assay, with and without S9	None of the samples analysed (e.g. extracts or PM suspensions) elicited a significant positive response	Chen & Guo (2007)

Supplemental Table S8 (continued)

Geographical location	Test article	*Salmonella* strains[a]/assay version	Results	Reference
Kowloon, Hong Kong Special Administrative Region, China (1995–1996)	TSP. DCM Soxhlet extraction	TA98, TA100, plate incorporation assay, with and without S9	Mutagenic potency (per m^3) highest in December (winter) and lowest in August (summer). Maximum potency on TA98 without S9 ~45 rev/m^3	Mo et al. (1998)
Riyadh, Saudi Arabia	Airborne PM from roadside location, collected on GFFs with constant-flow sampler. Ac sonication extraction	TA98, TA100, TA102, plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Mutagenic potency (per µg of EOM) on TA98 similar with and without S9	al-Khodairy & Hannan (1997)
Riyadh, Saudi Arabia	Airborne PM before, during, and after oil well fires in Kuwait, collected on GFFs. Ac sonication extraction	TA98, plate incorporation assay, with and without Aroclor 1254-induced rat liver S9	Marked increase in potency without S9 (per µg of EOM) during oil well fires. Potency on TA98 without S9 ~8 rev/m^3 during fires; ~1 rev/m^3 before and after fires	al-Khodairy et al. (1998)
Jeddah, Saudi Arabia (2004)	PM_{10} from 10 urban sites and 1 reference site, collected on GFFs with high-volume sampler. Ac Soxhlet extraction	TA98, plate incorporation assay, with and without PB/5,6-BF-induced rat liver S9	Mutagenic potency (per m^3) increased with S9 activation, and highest at location near refuse incinerator and heavy diesel traffic. Maximum mutagenic potency on TA98 with S9 ~56 rev/m^3. Potency at residential and reference sites S9 ~2–15 rev/m^3	Elassouli et al. (2007)
Chiang Mai, Thailand (1998–1999)	PM_{10} or $PM_{2.5}$ from 5 urban sites, collected on Teflon-impregnated GFFs or Teflon membrane filters with portable samplers. DCM sonication extraction	TA100, plate incorporation assay, with and without rat liver S9	Mutagenic potency (per m^3) elevated at high-traffic sites, and higher with S9. At one site, potency elevated in winter months. Maximum potency on TA100 with S9 ~30 rev/m^3; without S9 ~22 rev/m^3	Vinitketkumnuen et al. (2002)

[a] YG1021: TA98 with plasmid pYG216, NR-overproducing strain; YG1024: TA98 with plasmid pYG219, OAT-overproducing strain; YG1041: TA98 with plasmid pYG233, NR- and OAT-overproducing strain; YG1026: TA100 with plasmid pYG216, NR-overproducing strain; YG1029: TA100 with plasmid pYG219, OAT-overproducing strain; YG1042: TA100 with plasmid pYG233, NR- and OAT-overproducing strain.

Ac, acetone; 5,6-BF, 5,6-benzoflavone; B[*a*]P, benzo[*a*]pyrene; BZ, benzene; Chl, chlorophyll; CO, carbon monoxide; CX, cyclohexane; DBA, dibenz[*a*,*h*]anthracene; DCM, dichloromethane; DMSO, dimethyl sulfoxide; DNPs, dinitropyrenes; EOM, extractable organic matter; EtOH, ethanol; FBS, fetal bovine serum; GFFs, glass-fibre filters; HPLC, high-performance liquid chromatography; MeOH, methanol; NO, nitrogen oxide; NO_x, nitrogen oxides; NR, nitroreductase; OAT, *O*-acetyltransferase; PAC, polycyclic aromatic compounds; PAHs, polycyclic aromatic hydrocarbons; PB, phenobarbital; PCB, polychlorinated biphenyl; PM, particulate matter; PM_{10}, particulate matter with particles of aerodynamic diameter < 10 µm; $PM_{2.5}$, particulate matter with particles of aerodynamic diameter < 2.5 µm; PUF, polyurethane foam; rev, revertants; SVOCs, semivolatile organic compounds; TLC, thin-layer chromatography; TSP, total suspended particles.

Supplemental Table S9 Summary of studies that used bacterial mutagenicity assays (e.g. Ames assay) to assess the ability of outdoor air to induce genetic mutations – Oceania (Australia and New Zealand)

Geographical location	Test article	*Salmonella* strains[a]/assay version	Results	Reference
South Island, New Zealand (2001–2002)	PM_{10} from 3 urban and residential locations, collected on quartz filters with high-volume sampler. Sequential Soxhlet extraction with DCM and MeOH	TA98, plate incorporation assay, without rat liver S9	Mutagenic potency (per m^3) substantially higher in winter, and elevated in urban areas. 74% of winter samples elicited positive responses; 25% of summer samples. Maximum potency on TA98 ~11 rev/m^3	Brown et al. (2005)
North Island, New Zealand (2005)	PM_{10} and $PM_{2.5}$ from 2 residential locations, collected on GFFs or quartz filters with high-volume sampler. DCM Soxhlet extraction	TA98, fluctuation assay, without S9 activation	Substantial increases in potency (per m^3) in winter; no significant seasonal difference in potency (per µg of EOM). Potency higher for $PM_{2.5}$, compared with PM_{10}. Potency significantly correlated with PAH levels. Estimated that wood smoke made larger contribution than mobile sources. Maximum potency on ~30 rev/m^3	Cavanagh et al.(2009)

[a] YG1021: TA98 with plasmid pYG216, NR-overproducing strain; YG1024: TA98 with plasmid pYG219, OAT-overproducing strain; YG1041: TA98 with plasmid pYG233, NR- and OAT-overproducing strain; YG1026: TA100 with plasmid pYG216, NR-overproducing strain; YG1029: TA100 with plasmid pYG219, OAT-overproducing strain; YG1042: TA100 with plasmid pYG233, NR- and OAT-overproducing strain.

DCM, dichloromethane; EOM, extractable organic matter; GFFs, glass-fibre filters; MeOH, methanol; NR, nitroreductase; OAT, *O*-acetyltransferase; PAHs, polycyclic aromatic hydrocarbons; PM_{10}, particulate matter with particles of aerodynamic diameter < 10 µm; $PM_{2.5}$, particulate matter with particles of aerodynamic diameter < 2.5 µm; rev, revertants.

Supplemental Table S10 Summary of studies that used plant assays to assess the ability of outdoor air to induce cytogenetic damage

Geographical location	Sites examined	Test system/exposure	End-point examined	Results obtained	Reference
Perugia, Italy	3 locations: no significant local source, residential heating and traffic, high-traffic urban location	*Tradescantia* clone 4430, in situ exposures of cuttings for 24 h	Induction of MN (per 100 tetrads) in pollen mother cells	Significant increase in MN (relative to indoor control) for all 3 sites during winter. Weaker but significant increase in MN also observed in March and May	Villarini et al. (2009)
Perugia and Brescia, Italy	5 locations: heavily industrialized district, bypass road, near railway station, car tunnels in Perugia and Brescia	*Tradescantia* clone 4430, in situ exposures of inflorescences for 24 h. Perugia tunnel exposure for 1–5 h	Induction of MN (per 100 tetrads) in pollen mother cells	Significant increase in MN frequency only for Perugia tunnel 1 h and 5 h exposures. No significant increases in MN at other sites	Monarca et al. (1999)
Caserta, Italy	17 locations in Caserta affected by different levels of vehicle traffic, winter and summer	*Tradescantia* clone 4430, in situ exposures of inflorescences for 24 h	Induction of MN (per 100 tetrads) in pollen mother cells	Significant increase in MN for all sites in winter. Weaker response in summer, with significant increase at 2 of 17 sites	Isidori et al. (2003)
Stuttgart, Germany	8 locations near a municipal waste incinerator (400 m to 1400 m)	*Tradescantia* clone 4430, in situ exposures of cuttings for 6–24 h	Induction of MN (per 100 tetrads) in pollen mother cells	Significant increase in MN frequency for 9 h and 24 h exposures. Response dependent on distance from incinerator and wind direction	Fomin & Hafner (1998)
Bratislava, Slovakia	5 locations in an urban/industrial area (vehicular traffic, municipal incinerator, and several industries)	*Tradescantia paludosa* clone 03, in situ exposures for 10–62 d	Induction of MN (per 100 tetrads) in pollen mother cells	Significant increase in MN frequency, with highest response near agrochemical factory, followed by glass industry and urban traffic. No significant increase near incinerator	Misík et al. (2006)
Bratislava, Slovakia	One location downwind of a municipal incinerator (150 m) and a petrochemical plant	*Tradescantia paludosa* clone 03, in situ exposures in pots for 10 d	Induction of MN (per 100 tetrads) in pollen mother cells	Significant increase in MN frequency for all 12 exposures in summer 1997–2000; 1 of 9 exposures during summer 2003–2005 elicited a positive response	Misík et al. (2007)
10 European cites	65 urban and rural sites in Barcelona, Valencia, Copenhagen, Dusseldorf, Stuttgart, Edinburgh, Klagenfurt, Lyon, Nancy, and Verona	*Tradescantia* clone 4430, in situ exposures of cuttings for 30 h, 2–2.5 m above ground	Induction of MN (per 100 tetrads) in pollen mother cells	No relative increases in MN frequency for 85% of the assessments. Significant inter-site differences in MN frequencies within a city only observed for cities with heavy-traffic locations (Stuttgart, Lyon, and Valencia)	Klumpp et al. (2006)
Urban and rural sites in São Paulo state, Brazil	2 urban sites in the São Paulo metropolitan area and 2 rural sites outside São Paulo	*Tradescantia pallida* (Rose) Hunt. cv. *purpurea* Boom, sentinel plant monitoring and 5-month in situ exposures of potted specimens	Induction of MN (per 100 tetrads) in pollen mother cells	Significant (2–3-fold) increase in MN frequency at urban sites, relative to rural sites. Rural sites not significantly different from control	Guimarães et al. (2000)

Supplemental Table S10 (continued)

Geographical location	Sites examined	Test system/exposure	End-point examined	Results obtained	Reference
Córdoba City, Argentina.	3 urban locations: city centre, university campus, and residential.	*Tradescantia pallida*, 6-month in situ exposures in pots	Induction of MN (per 100 tetrads) in pollen mother cells	Significant increase in MN frequency, and significant effect of site. MN frequency at residential site significantly lower than at other sites. Positive correlation between MN frequency and TSP for the city centre site	Carreras et al. (2006, 2009)
Cities in Poland and Belgium	6 locations in Płock (Poland), 8 locations in Warsaw (Poland), 4 locations near Cour-au-Bois dump site (Belgium), 9 sites near Lubna dump site (Poland)	*Tradescantia* clone 4430, in situ exposures of cuttings for 6 h	Induction of MN (per 100 tetrads) in pollen mother cells	Significant increases in MN frequency for urban/industrial sites. Elevated levels at high-traffic sites. Elevated MN frequencies at sites close to landfills	Sadowska et al. (2001)
Sites in Poland and Belgium	3 locations in Poland near a coal-fired power plant, 3 locations in Belgium near a waste disposal site, 3 locations in Belgium near a closed waste disposal site	*Tradescantia* clone 4430, in situ exposures of cuttings for 6–8 h	Induction of MN (per 100 tetrads) in pollen mother cells	Significant increases in MN frequency for all sites near the power plant, and locations at both waste sites, relative to field controls	Sadowska et al. (1994)
Sites in Belgium	20 locations in Belgium at or near a large landfill	*Tradescantia* clone 4430, in situ exposures cuttings for 8 h	Induction of MN (per 100 tetrads) in pollen mother cells	Significant increases in MN frequency at all sites, with highest response, relative to field controls, close to landfill and highways	Sadowska et al. (1999)
Amazon region, Brazil	5 locations in Tangará da Serra region	*Tradescantia pallida*, in situ 5-month exposures of potted specimens and monitoring of sentinel specimens	Induction of MN (per 100 tetrads) in pollen mother cells	Significant increase in MN frequency, relative to control site (Chapada dos Guimarães) in dry season only. Positive correlation between MN frequency and $PM_{2.5}$ level	Sisenando et al. (2011)
Minas Gerais state, Brazil	4 urban locations in Uberlândia City, and a control (garden) site	*Tradescantia pallida* (Rose) Hunt. cv. *purpurea* Boom, 18 h in situ exposures in "exposure boxes" (pots)	Induction of MN (per 100 tetrads) in pollen mother cells	Significant elevation in MN frequency relative to control site. Higher levels in winter, and positive correlation between MN frequency and traffic density (vehicles/day)	Pereira et al. (2013)
Bahia state, Brazil	3 location in Feira de Santana with varying traffic density	*Tradescantia pallida*, in situ exposures of potted specimens and monitoring of sentinel specimens	Induction of MN (per 100 tetrads) in pollen mother cells	Significant elevation in MN frequency, correlation between frequency and intensity of vehicular traffic. Active in situ exposures yielded higher MN values relative to passive sentinel exposures	Meireles et al. (2009)

Supplemental Table S10 (continued)

Geographical location	Sites examined	Test system/exposure	End-point examined	Results obtained	Reference
Rio Grande do Sul state, Brazil	4 locations in the metropolitan area of Porto Alegre	*Tradescantia pallida* var. *purpurea*, 24 h in situ exposures in pots	Induction of MN (per 100 tetrads) in pollen mother cells	Significant elevation in MN frequency at urban site (Estância Velha), relative to rural area and indoor control	Costa & Droste, (2012)
Urban and rural sites in São Paulo state, Brazil	28 sites in São José dos Campos	*Tradescantia pallida*, in situ exposures in pots for 20 wk	Induction of MN (per 100 tetrads) in pollen mother cells	Significant elevations in MN frequency at sites with high traffic. Significant association between MN frequency and human cancer incidence	Mariani et al. (2009)
Urban and rural sites in metropolitan area of São Paulo, Brazil	4 urban locations in the city of Santo André and a reference site	*Tradescantia pallida* cv. *purpurea*, in situ exposures in pots, biweekly sample collection for 12 months	Induction of MN (per 100 tetrads) in pollen mother cells	Significant elevations in MN frequency at urban sites relative to reference. Highest levels at sites with high traffic density. Weather changes also associated with increases in MN frequency	Savóia et al. (2009)
Varanasi City, India	3 urban sites and 1 reference site	*Tradescantia pallida* cv. *purpurea*, in situ exposures in pots for 2, 4, or 6 months	Induction of MN (per 100 tetrads) in pollen mother cells	Significant elevation in MN frequency, and significant site effect, with highest responses at sites with higher levels of TSP and PAHs	Prajapati & Tripathi (2008)
Žilina City, Slovakia	2 sites in proximity to a landfill (Považský Chlmec) and an industrial complex (Dubeň)	*Tradescantia paludosa* clone 03, in situ exposures in pots, weekly sample collection for 12 months	Induction of MN (per 100 tetrads) in pollen mother cells	Significant elevation in MN frequency, with highest levels observed at the industrial area	Solenská et al. (2006)
Bahia state, Brazil	2 areas in the municipality of Senhor do Bonfim	*Tradescantia pallida* (Rose) Hunt. cv. *purpurea* Boom, in situ exposures in pots, monthly sampling for 1 year	Induction of MN (per 100 tetrads) in pollen mother cells	Significant increase in MN frequency relative to control site, with highest responses at location with highest traffic density	Andrade Jr. et al. (2008)
São Paulo, Brazil	Downtown São Paulo. Water extracts of PM_{10}	*Tradescantia pallida* (Rose) Hunt. cv. *purpurea*, 30 minutes exposure to water extract	Induction of MN (per 100 tetrads) in pollen mother cells	Significant dose-dependent increase in MN at 1.5 and 3.0 equiv mg of PM/L. At highest exposure, 3-fold increase in MN frequency compared with control	Batalha et al. (1999)
Brescia, Italy	2 locations: urban (heavy car traffic), residential (lower traffic)	*Tradescantia* inflorescences exposed for 24 h to PM_{10} extract in DMSO	Induction of MN (per 100 tetrads) in pollen mother cells	Extract of PM from heavy-traffic site induced significant increase in MN frequency	Monarca et al. (1999)
São Paulo, Brazil	Downtown São Paulo. Water extracts of $PM_{2.5}$ collected during and after a bus strike	*Tradescantia pallida* cuttings exposed to PM water extracts for 8 h	Induction of MN (per 100 tetrads) in pollen mother cells	Significant reduction in MN frequency during bus strike (i.e. for 1 mg of PM equiv/L)	Carvalho-Oliveira et al. (2005)

Supplemental Table S10 (continued)

Geographical location	Sites examined	Test system/exposure	End-point examined	Results obtained	Reference
Córdoba City, Argentina	University campus, 24 h TSP sample. DCM sonication extraction	*Tradescantia pallida* (Rose) Hunt. cv. *purpurea* Boom, 8 h exposure of cuttings to seasonal composites of TSP extracts (in DMSO)	Induction of MN (per 100 tetrads) in pollen mother cells	Significant elevation in MN frequency for winter, relative to autumn or summer. However, none of the samples showed significant elevation in MN frequency relative to DMSO control	Carreras et al. (2009, 2013)
Mato Grosso state, Brazil	PM_{10} collected in Tangará da Serra during biomass burning. DCM sonication extraction	*Tradescantia pallida* cuttings exposed to PM extracts for 8 h	Induction of MN (per 100 tetrads) in pollen mother cells	Significant elevation in MN frequency during the period of most intense biomass burning (i.e. August to October)	de Oliveira Alves et al. (2011)
Slovenia	2 locations in Slovenia: 1 densely polluted (Zagreb-Žitnjak) and 1 minimally polluted (Velika Gorica)	*Allium cepa* roots exposed to rainwater or melted snow for 2 d or 5 d	Induction of CAs in root tip cells	Significant increase in CA frequency relative to laboratory control, with highest response for densely polluted site. Early collection times after start of precipitation tended to yield higher levels of CAs	al-Sabti (1989)
4 regions in Slovenia	8 locations in the Šalek Valley, the Zosavje region, the Upper Meža Valley, and the Ljubljana Basin exposed to power plant, industrial, or urban emissions	*Allium cepa* L. var. *ascalonicum*, in situ exposures in pots for 3 months	Induction of CAs in metaphase and anaphase of root tip cells	Some indication of increases in CAs at sites near a major thermal power plant, and an urban site (Ljubljana)	Glasenčnik et al. (2004)
L'Aquila, Italy	Airborne PM between 2.5 µm and 10 µm, and between 0.4 µm and 2.5 µm, collected with 8-stage cascade impactor	*Daucus carota* cell cultures exposed to suspended PM for 2–5 d	Induction of MN	Significant increase in MN frequency for fine and coarse PM after exposure for 5 d. Coarse PM induced a significant response for the longer exposure only. Greater response to fine PM	Poma et al. (2002)
L'Aquila, Italy	Airborne PM between 2.5 µm and 10 µm, and between 0.4 µm and 2.5 µm, collected with 8-stage cascade impactor	*Zea mays* root tip cells exposed to suspended PM for 20 h (SCE) or 48 h (MN)	Induction of MN or SCEs	Significant increase in MN frequency for all samples of fine PM, and 3 of 12 coarse samples. Significant increase in SCE frequency for 11 of 12 fine PM samples and 6 of 12 coarse PM samples	Poma et al. (2002)

CAs, chromosomal aberrations; d, day or days; DCM, dichloromethane; DMSO, dimethyl sulfoxide; equiv, equivalent; h, hour or hours; MN, micronuclei; PAHs, polycyclic aromatic hydrocarbons; PM, particulate matter; PM_{10}, particulate matter with particles of aerodynamic diameter < 10 µm; $PM_{2.5}$, particulate matter with particles of aerodynamic diameter < 2.5 µm; SCEs, sister chromatid exchanges; TSP, total suspended particles; wk, week or weeks.

Supplemental Table S11 DNA adducts in experimental systems exposed to extracts of air particles: in vitro studies

Material studied	Experimental system	Method of analysis	Results	Reference
Extracts of air samples from Prague (Czech Republic), Košice (Slovakia), and Sofia (Bulgaria)	Human hepatoma HepG2 cells, human diploid lung fibroblasts HEL, and human monocytic leukaemia cell line THP-1	^{32}P-postlabelling	Winter samples: Prague > Sofia > Košice. Summer samples: Košice > Sofia > Prague	Sevastyanova et al. (2007)
Extracts of SRM 1649a dust sample	Rat liver epithelial WB-F344 cells	^{32}P-postlabelling	Crude extracts and non-polar fractions gave rise to DNA adducts; polar fraction did not	Andrysík et al. (2011)
Extracts of air particles from Teplice and Prachatice, Czech Republic	Cultured rat hepatocytes and Chinese hamster lung V79NH cells	^{32}P-postlabelling	Highest DNA binding activity in fractions containing PAHs and nitro-PAHs	Topinka et al. (2000)
Extracts of air particles from Teplice, Czech Republic	Calf thymus DNA with and without S9 liver fraction	^{32}P-postlabelling	Highest adduct formation with neutral (aromatic) fraction	Binková et al. (1998)
Extracts of air particles from Teplice and Prachatice, Czech Republic	Calf thymus DNA with and without S9 liver fraction	^{32}P-postlabelling	Seasonal differences significant (with and without S9). Location difference significant (without S9). DNA adducts were mainly PAH-like	Binková et al. (1999)
Extracts of air particles from Prague city centre and suburban area and Teplice, Czech Republic	Calf thymus DNA with and without S9 liver fraction	^{32}P-postlabelling	Winter > summer for all 3 locations. Differences between locations not significant	Binková et al. (2003)
Extracts of air particles from Ostrava region and Třeboň, Czech Republic	Calf thymus DNA with and without S9 liver fraction	^{32}P-postlabelling	DNA adduct-forming activity of Ostrava (industrial) > Ostrava (urban) > Třeboň (rural)	Topinka et al. (2011)

PAH, polycyclic aromatic hydrocarbon; SRM, standard reference mixture.

Supplemental Table S12 Summary of studies on protein adducts in humans

Location	Study populations	Method of analysis; source of protein	Results	Reference
Sweden	Urban bus drivers (26), suburban bus drivers (21), taxi drivers (19), controls (21, hospital workshop workers)	Immunoassay for PAH–plasma protein adducts; blood plasma	Taxi drivers had significantly higher adduct levels than controls ($P < 0.001$), but bus drivers did not	Hemminki et al. (1994)
Denmark	Non-smoking men from rural ($n = 29$) and urban ($n = 73$) areas of Denmark	ELISA of PAH–albumin adducts in serum	In contrast to DNA adducts, which correlated with exposure levels, albumin adducts were non-significantly elevated in the rural group	Nielsen et al. (1996a)
Denmark	Pregnant women resident in a rural area (21 smokers, 30 non-smokers), in suburbs (37 non-smokers), and in the city of Aarhus (40 non-smokers)	ELISA of PAH–albumin adducts in serum; maternal and cord blood cells	Among non-smoking women, adduct levels significantly lower in suburban group than in city dwellers ($P = 0.0173$), but rural dwellers not significantly different from city dwellers. Levels in cord blood lower than in maternal blood ($P < 0.000$) and slightly higher in smokers and rural residents than in non-smokers and suburban and city dwellers	Autrup & Vestergaard (1996)
Czech Republic	30 women in Teplice (high pollution, exposed); 30 women in Prachatice (low pollution, control)	ELISA of PAH–albumin adducts in serum	No difference in albumin adducts between the 2 groups	Binková et al. (1996)
Poland	Residents living close to coke oven plants at Gliwice ($n = 13$), Bytom ($n = 23$), and Świętochłowice ($n = 12$) (Silesia; $n = 36$) and rural residents of Biała Podlaska ($n = 45$)	ELISA of PAH–albumin adducts in serum	Mean level of adducts in rural controls significantly lower than in exposed Silesia residents (summer samples) ($P < 0.001$), but were not correlated with air levels of B[*a*]P (stationary sampling)	Kure et al. (1997)
Germany	Residents of city and suburbs of Munich ($n = 69$)	HPLC and GC-MS of B[*a*]P–albumin adducts and B[*a*]P–haemoglobin adducts in blood	Adduct levels did not correlate with estimated dietary intake of B[*a*]P. Levels tended to be higher in suburban residents (borderline significance for B[*a*]P–albumin, $P = 0.056$)	Scherer et al. (2000)
Germany	Children aged 7 years living in Munich ($n = 34$), Augsburg ($n = 126$), and Eichstätt ($n = 64$) (total populations, 1.3 million, 250 000, and 13 000, respectively)	Aromatic amine–haemoglobin adducts measured by GC-MS in blood (4-aminobiphenyl, *o*-toluidine, *m*-toluidine, *p*-toluidine, and *o*-anisidine)	Adduct levels were highest in children from Munich, intermediate in children from Augsburg, and lowest in children from Eichstätt. Exposure to ETS did not significantly increase adduct levels	Richter et al. (2001)
Thailand	Police officers in Bangkok; traffic police (high exposure, $n = 44$) and office-based police (low exposure, $n = 45$)	ELISA of PAH–albumin adducts in serum	Adduct levels significantly higher in exposed group ($P = 0.001$)	Ruchirawat et al. (2002)
Italy	Newspaper vendors in Milan: high-traffic-exposed ($n = 30$) and low-traffic-exposed ($n = 23$)	Immunoaffinity chromatography for B[*a*]P tetrol from haemoglobin hydrolysate followed by GC-MS analysis	Differences between high- and low-exposure groups significant for non-smokers, but not for smokers	Pastorelli et al. (1996)

B[*a*]P, benzo[*a*]pyrene; ELISA, enzyme-linked immunosorbent assay; ETS, environmental tobacco smoke; GC-MS, gas chromatography-mass spectrometry; HPLC, high-performance liquid chromatography; PAHs, polycyclic aromatic hydrocarbons.

Supplemental Table S13 DNA strand breaks in acellular test systems

Particles	Substrate	Extraction	Method	Effect	Reference
PM_{10} from Edinburgh, United Kingdom	Phage DNA	Water (sonication)	Supercoil relaxation	Increased generation of SB, which was diminished by treatment with mannitol	Donaldson et al. (1997)
PM_{10} from Edinburgh, United Kingdom	Phage DNA	Water (sonication)	Supercoil relaxation	Increased generation of SB, which was diminished by treatment with mannitol or DFO	Gilmour et al. (1996)
$PM_{2.5}$ from Baton Rouge, Louisiana, USA	Phage DNA	PBS (vortexing)	Supercoil relaxation	Increased DNA relaxation, which was decreased by superoxide or catalase treatment	Dellinger et al. (2001)
SRM 1648 and SRM 1649	Phage DNA with or without ascorbate	Baghouse	Supercoil relaxation	Increased level of SB when ascorbate was present. SRM 1649 more potent than SRM 1648	Smith & Aust (1997)
Coal fly ash from a dumping site of a thermal power plant in Aligarh, India	Calf thymus DNA	DMSO (0.5%) or water (sonication)	Alkaline unwinding	Increased generation of SB by DMSO (0.5%) and aqueous extract	Dwivedi et al. (2012)
TSP from an unknown site in London, United Kingdom (collected in 1958)	Plasmid DNA	Water (shaking)	Supercoil relaxation	Concentration-dependent increase in level of SB	Whittaker et al. (2004)
Different size fractions of PM_{10} from Leeds, United Kingdom	pBR322	Water (vortexing)	Supercoil relaxation	Small size fractions most potent in generation of SB	Healey et al. (2005)
Fine PM, coarse PM, or PM_{10} from an urban site 2.5 miles from a landfill site	Plasmid DNA	Not reported	Supercoil relaxation	Fine particles more potent than coarse, and PM_{10} least potent	Koshy et al. (2009)
Aqueous extract of PM_{10} from a traffic site in Leeds, United Kingdom	Plasmid DNA	Water	Supercoil relaxation	Small particles more potent than large particles, which correlated with the level of iron	Lingard et al. (2005)
PM_{10} and $PM_{2.5}$ from Barcelona, Spain	Plasmid DNA	Water (sonication)	Supercoil relaxation	PM_{10} more potent than $PM_{2.5}$	Reche et al. (2012)
PM_{10} and $PM_{2.5}$ from Beijing, China	Plasmid DNA	Water (vortexing)	Supercoil relaxation	$PM_{2.5}$ samples generated more SB than PM_{10} samples	Shao et al. (2006)
Fine and coarse particles from Cardiff, United Kingdom	Phage DNA	Water (vortexing)	Supercoil relaxation	Coarse particles more potent than fine particles	Greenwell et al. (2002)
Particles from Port Talbot, United Kingdom, sampled during different wind directions	Plasmid DNA	Water (vortexing)	Supercoil relaxation	Highest activity on mass basis of samples collected during wind direction from a location with hilly country and motorway. Association between strand scission activity and metal content	Moreno et al. (2004)

Supplemental Table S13 (continued)

Particles	Substrate	Extraction	Method	Effect	Reference
$PM_{2.5}$ from urban or suburban sites in Shanghai, China	Plasmid DNA	Water (vortexing)	Supercoil relaxation	Samples from urban sites most potent. Seasonal variation in potency (winter more potent than summer)	Senlin et al. (2008)
$PM_{2.5}$ and PM_{10} samples collected at Beijing, Nankou town, and a clean site, Shisanling Reservoir, China	Plasmid DNA	Water (sonication)	Supercoil relaxation	Extracts of $PM_{2.5}$ and PM_{10} caused SB generation, with TM50 (level causing 50% of SB) ranging from 10 to 1000 μg/mL, dependent on the sites and sampling time. Generally, $PM_{2.5}$ samples more potent than PM_{10} samples. Samples collected during sandstorm less potent than non-sandstorm samples	Shi et al. (2004)
PM_{10} samples from Lanzhou city and a suburban area in China during 4 seasons	Plasmid DNA	Water (sonication)	Supercoil relaxation	Average values of TD20 (level causing 20% of SB) were 17, 625, 56, and 260 μg/mL in winter, spring, summer, and autumn, respectively, for PM_{10} suspension solution from Lanzhou city. Water extracts caused slightly lower level of SB with higher TD20. Suburban PM_{10} samples showed higher TD20 than Lanzhou sample. Particles collected during dust storm episodes or after days with rain showed lower SB generation activity with TD20 > 1000 μg/mL. TD20 values were negatively correlated with metal concentration	Xiao et al. (2009)
PM_{10} samples collected at 3 sites in Macao Special Administrative Region, China	Plasmid DNA	Water (sonication)	Superoxide relaxation	TD30 values (level causing 30% of SB) were 3, 10, and 20 μg/mL for whole PM_{10} suspension samples from Sun Yat Sen Municipal Park, Avenida de Horta e Costa, and Macao University, respectively. Water extracts showed slightly high TD30 values, with 60, 63, and 80 μg/mL for the 3 sites, respectively	Shen et al. (2009)

DFO, deferoxamine; DMSO, dimethyl sulfoxide; PBS, phosphate-buffered saline; PM, particulate matter; PM_{10}, particulate matter with particles of aerodynamic diameter < 10 μm; $PM_{2.5}$, particulate matter with particles of aerodynamic diameter < 2.5 μm; SB, strand breaks; SRM, standard reference mixture.

Supplemental Table S14 Oxidatively damaged DNA in lung tissue of animals

Particles	Animal	Extraction	Dose and duration	Effect	Reference
PM_{10} collected during a dust storm from the roof of a building in Incheon, Republic of Korea	Mice	PBS	0.5 mg/mouse twice/wk for 12 wk (total dose, 12 mg/mouse), and killed at 24 h after the last exposure	8-oxodG (immunohistochemistry) in lungs	Hwang et al. (2010)
Intratracheal instillation of SRM 1649	*ApoE*$^{-/-}$ mice	NA	0.5 mg/kg at 26 h and 2 h before being killed	Unaltered levels of FPG-sensitive sites (comet) in lung tissue	Vesterdal et al. (2012)
Intratracheal instillation of PM from a town with many wood stoves and a rural area, Denmark	Rats	Mechanical collection from plates	0.64 mg/kg, and killed at 24 h	Unaltered levels of 8-oxodG and etheno adducts (HPLC)	Danielsen et al. (2010)

FPG, formamidopyrimidine DNA glycosylase; h, hour or hours; HPLC, high-performance liquid chromatography; NA, not applicable; 8-oxodG, 8-oxo-7,8-dihydro-2′ -deoxyguanosine; PBS, phosphate-buffered saline; PM, particulate matter; PM_{10}, particulate matter with particles of aerodynamic diameter < 10 μm; SRM, standard reference mixture; wk, week or weeks.

Supplemental Table S15 Oxidatively damaged nucleobases in cultured cells

Particles	Cells	Extraction	Concentration and time	Effect	Reference
Urban street (TSP), Copenhagen, Denmark	A549	Water (ultrasonication)	2.5–100 µg/mL	Concentration-dependent increase in FPG sites (comet)	Danielsen et al. (2008)
Particles from a street tunnel in Oslo, Norway, during seasons with or without use of studded tyres	A549 and THP-1	Scraping off the filter	2.5–200 µg/mL for 3 h	Increased FPG-sensitive sites in A549 cells (comet)	Danielsen et al. (2009)
PM from a town with many wood stoves and a rural area, Denmark	A549 and THP-1	Mechanical collection from plates	2.5–100 µg/mL for 3 h	Concentration-dependent increase in FPG-sensitive sites in A549 and THP-1 cells (comet). Unaltered levels of 8-oxodG and etheno adducts in A549 cells	Danielsen et al. (2011)
PM_{10} from a busy street in Stockholm, Sweden	A549	Water (vortexing or sonication)	10 µg/cm² (8-oxodG) for 4 h	Unaltered 8-oxodG levels (HPLC-ECD)	Karlsson et al. (2005)
$PM_{2.5}$ or PM_{10} from city background site in Milan, Italy	BEAS-2B	Water (ultrasound)	25 µg/cm² for 24 h	Unaltered levels of FPG-sensitive sites (comet)	Gualtieri et al. (2011)
Aqueous extract of $PM_{2.5}$ from Piedmont, Italy	A549	Water (ultrasound)	15–7 m³ equiv for 24 h	Higher induction of FPG sites (comet) by aqueous extracts from industrial site compared with urban and highway sites	Bonetta et al. (2009)
PM in different size fractions from urban and rural sites, United Kingdom	A549	Water (sonication)	100 µg/cm² for 24 h	Increased levels of FPG-sensitive sites (comet), with higher dependency on locations than on particle sizes	Wessels et al. (2010)
Coarse and fine particles from Düsseldorf, Germany	A549	Water (sonication)	50 µg/mL for 2 h	Coarse and fine PM generated similar extent of 8-oxodG (antibody-based detection)	Shi et al. (2003)
$PM_{2.5}$ from Dunkirk, France	A549	Mechanical collection from plates	6.3–31.6 µg/cm² for 24–72 h	Concentration-dependent increase in level of 8-oxodG (ELISA) at all time points	André et al. (2011)
PM from Dunkirk, France	L132	Mechanical collection from plates	19–75 µg/mL for 24–72 h	Concentration- and time-dependent increase in level of 8-oxodG (ELISA)	Garçon et al. (2006)
EOM of PM_{10} from Prague (Czech Republic), Košice (Slovakia), and Sofia (Bulgaria)	HepG2	DCM	10–250 µg/mL for 2–48 h	Unaltered levels of FPG-sensitive sites (comet), except EOM of PM_{10} from Kosice in summer	Gábelová et al. (2007)
SRM 1649, ROFA, Arizona desert dust, or urban air dust from Düsseldorf, Germany	BEAS-2B	NA	400 mg/mL for 2 h	Increased 8-oxodG (HPLC-ECD)	Prahalad et al. (2001)

Supplemental Table S15 (continued)

Particles	Cells	Extraction	Concentration and time	Effect	Reference
Coal fly ash from a power plant in Arnhem, Netherlands	RLE	Not specified	40 cm^2/mL or particles/mL for 18 h	Different potency of particles to generate 8-oxodG (HPLC-ECD)	van Maanen et al. (1999)
EOM of PM_{10} from Teplice, Czech Republic	HepG2	DCM	1–50 μg/mL for 24 h	Increased ENDOIII/FPG sites, although not concentration-dependent relationship	Lazarová & Slamenová (2004)
EOM of $PM_{2.5}$ from the traffic area in Suwon, Republic of Korea	BEAS-2B	DCM (sonication)	50 μg/mL	Increased levels of ENDOIII/FPG sites	Oh et al. (2011)
EOM of PM_{10} from an industrial site in France	HepG2	DCM (Soxhlet extractor)	12 μg/mL of B[*a*]P for 24 h	Increased levels of 8-oxodG (HPLC-MS/MS)	Tarantini et al. (2009)
EOM of PM_{10} from Prague, Czech Republic	HepG2 and lung fibroblasts	DCM	1–100 mg/mL for 24–48 h	Increased levels of 8-oxodG (ELISA) in HepG2 cells, but not in lung fibroblasts. Little variation in genotoxicity between different seasons	Hanzalova et al. (2010)
EOM of PM_{10} from Kaifaqu district, Dalian, China	HepG2	Sequential extraction in DCM, acetone, and methanol	7.5–30 mg/mL for 1 h	Concentration-dependent increase in 8-oxodG (antibody-based) of samples from Kaifaqu (industrial area)	Jiang et al. (2011)

B[*a*]P, benzo[*a*]pyrene; DCM, dichloromethane; ECD, electrochemical detection; ELISA, enzyme-linked immunosorbent assay; ENDOIII, endonuclease III; EOM, extractable organic matter; equiv, equivalent; FPG, formamidopyrimidine DNA glycosylase; h, hour or hours; HPLC, high-performance liquid chromatography; MS, mass spectrometry; NA, not applicable; 8-oxodG, 8-oxo-7,8-dihydro-2′-deoxyguanosine; PM, particulate matter; PM_{10}, particulate matter with particles of aerodynamic diameter < 10 μm; $PM_{2.5}$, particulate matter with particles of aerodynamic diameter < 2.5 μm; ROFA, residual oil fly ash; SRM, standard reference mixture.

Supplemental Table S16 Association between particles and generation of oxidatively damaged nucleobases in acellular test systems

Particles	Substrate, co-oxidant	Extraction	Method	Effect	Reference
Coarse and fine particles from locations in North Rhine-Westphalia, Germany	Calf thymus DNA with H_2O_2	Water (sonication)	8-oxodG (dot blot)	Higher generation of 8-oxodG by PM from Duisburg than from rural location. Coarse and fine particles generated the same level of 8-oxodG	Shi et al. (2006)
Coarse and fine particles from Düsseldorf, Germany	Calf thymus DNA with H_2O_2	Water (sonication)	8-oxodG (dot blot)	Coarse PM generated more 8-oxodG than fine PM when compared at equal mass	Shi et al. (2003)
TSP from a busy street in Copenhagen, Denmark	Calf thymus DNA with H_2O_2	Water	8-oxodG (HPLC)	Concentration-dependent increase, but no difference between PM sampled on different days	Danielsen et al. (2008)
PM_{10} from Helsinki, Finland, collected during spring or winter	Calf thymus DNA with H_2O_2	Water and ethanol (sonication)	8-oxodG (immuno dot blot)	Concentration-dependent increase, without clear seasonal variation	Salonen et al. (2004)
Oil fly ash (from an electrostatic precipitator at a power plant in Niagara, New York, USA) and coal fly ash (from a power plant in USA)	dG or calf thymus DNA	Electrostatic precipitator	8-oxodG (HPLC-ECD)	Oil fly ash increased production of 8-oxodG, whereas coal fly ash did not. Reduced 8-oxodG production by DFO	Prahalad et al. (2000)
SRM 1649, urban air dust from Düsseldorf, Germany, Arizona desert dust, and ROFA	Calf thymus DNA	Baghouse	8-oxodG (HPLC-ECD)	Moderately increased production of 8-oxodG by SRM 1649 and urban air dust. No effect of Arizona desert dust and coal fly ash. Strong effect of ROFA and oil fly ash. Reduced effect by pre-treatment with catalase or DFO for ROFA and oil fly ash, whereas no protection against 8-oxodG generation by SRM 1649 and Düsseldorf particles	Prahalad et al. (2001)
SRM 1649 or its particles after extraction with organic solvents	dG	DCM, hexane, acetone, or DMSO	8-oxodG (HPLC)	Increased 8-oxodG production in water and lower production after extraction of organic material	Karlsson et al. (2004)
PM_{10} from an urban street in Stockholm, Sweden	dG with H_2O_2	Water (vortexing or sonication)	8-oxodG (HPLC-ECD)	Increased only in the presence of H_2O_2	Karlsson et al. (2005)
Fine particles from Duisburg, Germany	Calf thymus DNA with H_2O_2	Water (sonication)	8-oxodG (dot blot)	Increased only in the presence of H_2O_2. Filtrate without particles generated same level of 8-oxodG as suspensions of particles	Knaapen et al. (2002)
TSP, PM_{10}, and $PM_{2.5}$ from Athens, Greece	dG with H_2O_2	Water (sonication)	8-oxodG (HPLC-ECD)	$PM_{2.5}$, PM_{10}, and TSP generated 8-oxodG (8-oxodG level reported in the unusual unit of µg lesions per 10^6 dG)	Valavanidis et al. (2005)

Supplemental Table S16 (continued)

Particles	Substrate, co-oxidant	Extraction	Method	Effect	Reference
EOM from PM in different size fractions from the Czech Republic	Calf thymus DNA	DCM	8-oxodG (ELISA)	No difference between regions on mass concentration basis or different particle sizes (it is not possible to assess the effect of particles per se because the values in the negative control are not reported)	Rossner et al. (2010)
EOM from $PM_{2.5}$ from different areas of the Czech Republic	Calf thymus DNA	DCM	8-oxodG (ELISA)	No difference between regions on mass concentration basis (it is not possible to assess the effect of particles per se because the values in the negative control are not reported)	Topinka et al. (2011)
EOM from airborne particles in Maastricht, Netherlands	Salmon testis DNA	DCM (Soxhlet)	8-oxodG (HPLC-ECD)	Similar generation of 8-oxodG by $PM_{2.5}$, PM_{10}, and TSP samples. No association between traffic intensity and potency of the extracts	de Kok et al. (2005)
Coal fly ash from a dumping site of a thermal power plant in Aligarh, India	Calf thymus DNA	DMSO (0.5%) or water (sonication)	8-oxodG (antibody)	Increased generation of 8-oxodG by DMSO (0.5%) and aqueous extract	Dwivedi et al. (2012)

DCM, dichloromethane; DFO, deferoxamine; dG, deoxyguanosine; DMSO, dimethyl sulfoxide; ECD, electrochemical detection; ELISA, enzyme-linked immunosorbent assay; EOM, extractable organic matter; H_2O_2, hydrogen peroxide; HPLC, high-performance liquid chromatography; 8-oxodG, 8-oxo-7,8-dihydro-2′-deoxyguanosine; PM, particulate matter; PM_{10}, particulate matter with particles of aerodynamic diameter < 10 μm; $PM_{2.5}$, particulate matter with particles of aerodynamic diameter < 2.5 μm; ROFA, residual oil fly ash; SRM, standard reference mixture; TSP, total suspended particles.

Supplemental Table S17 In vivo and in vitro DNA damage response assays to assess the genotoxic activity of outdoor air

Geographical location	Test article	Assay/exposure system	End-point(s) examined	Results	Reference
In vivo					
Netherlands	Airborne PM. MeOH sonication extraction	Relative survival of *Escherichia coli* 343/753 (*uvrB*/*recA*) exposed to PM extracts in vivo via host-mediated assay (Balb/c mouse, intraperitoneal or intratracheal administration)	Induction of DNA damage response	No significant host-mediated induction of DNA damage	Heussen et al. (1990), Heussen & Alink (1990)
In vitro					
Netherlands.	Airborne PM at 2 urban locations and a rural control, collected on quartz filters with high-volume sampler. Ac/DCM (1:1) Soxtec extraction	*Salmonella typhimurium* TA1535/pSK1002, incubated for 2 h with extract in DMSO, with and without Aroclor 1254-induced rat liver S9	Induction of DNA damage (SOS) response as induction of *umu* operon (i.e. *umu* assay)	Significant dose-related (m^3 equiv/assay) increase in *umu* induction for both urban sites without S9. Response decreased with S9	Hamers et al. (2000)
Osaka area, Japan	Size-fractionated airborne PM from an urban site, collected with cascade impactor. DCM sonication extraction	*Salmonella typhimurium* NM3009 (NR- and OAT-enhanced) and NM2009 (OAT-enhanced), incubated for 3 h with extract in DMSO, with and without rat liver S9	Induction of DNA damage (SOS) response as induction of *umu* operon (i.e. *umu* assay)	Significant dose-related (m^3 equiv/assay) increase in *umu* induction on NM3009 without S9 and on NM2009 with S9. Greater response for NM3009, and magnitude of response increased for smaller particle size fractions (e.g. < 2.1 µm). Some coarser fractions (e.g. > 4.7 µm) failed to induce a significant response	Funasaka et al. (2003)
Osaka area, Japan	Airborne PM at an urban location, collected on quartz filters with high-volume sampler. DCM sonication extraction, fractionation on solid-phase columns	*Salmonella typhimurium* TA1535/pSK1002, NM3009 (NR- and OAT-enhanced) and NM2009 (OAT-enhanced), incubated for 2 h with extract in DMSO, with and without PB/5,6-BF-induced rat liver S9	Induction of DNA damage (SOS) response as induction of *umu* operon (i.e. *umu* assay)	Significant dose-related (m^3 equiv/assay) increase in *umu* induction. Strongest responses without S9 on NM3009 and with S9 on NM2009. Highest response without S9 associated with 2 fractions containing smaller 2–4-ring PAHs, and larger PAHs and nitrated PAHs	Oda et al. (2004)

Supplemental Table S17 (continued)

Geographical location	Test article	Assay/exposure system	End-point(s) examined	Results	Reference
Shanghai, China	TSP collected from 3 locations with variable levels of pollution and 1 reference site. Ac sonication extraction; extract separated into 5 fractions	*Salmonella typhimurium* TA1535/pSK1002, incubated for 2 h with extract in DMSO, with and without rat liver S9	Induction of DNA damage (SOS) response as induction of *umu* operon (i.e. *umu* assay)	Significant induction of DNA damage response for samples from 3 contaminated sites; higher induction at site with highest level of contamination. Higher response without S9	Lu et al. (1990)
Brno, Czech Republic	Airborne PM_{10} from an urban/industrial location, collected with cascade impactor. 6 PM size fractions, DCM extraction with Buchi automated extractor	*Escherichia coli* PQ37, incubated for 2 h with extract in DMSO, with and without S9 metabolic activation	Induction of DNA damage (SOS) response (SOS chromotest)	Significant dose-related (m^3 equiv/mL) increase in DNA damage response. Higher response without S9, and increase in response induction with decreasing PM size; maximum for < 0.45 µm. Highest concentration of PAHs associated with finest fraction	Čupr et al. (2013)
Bosnia and Herzegovina	Airborne PM (TSP) and SVOCs from 8 urban locations and 2 reference sites in Sarajevo and Tuzla, collected with high-volume sampler equipped with tandem GFF and PUF. DCM Soxhlet extraction	*Escherichia coli* PQ37, incubated for 2 h with pooled extracts (i.e. PUF and PM) in DMSO, with and without S9 metabolic activation	Induction of DNA damage (SOS) response (SOS chromotest)	Significant dose-related (m^3 equiv/assay) increase in DNA damage response for all samples. Higher responses without S9, higher levels at more industrialized locations in Tuzla, lowest responses at reference sites. Significant empirical relationships between sample potency, both with and without S9, and PAH concentration (ng/m^3)	Škarek et al. (2007a)
Czech Republic	Airborne PM ($PM_{2.5}$ or TSP) and SVOCs from 2 urban locations and 2 reference sites, collected with high-volume sampler equipped with tandem quartz filter and PUF. DEE/Hx (1:9) Soxhlet extraction	*Escherichia coli* PQ37, incubated for 2 h with pooled extracts (i.e. PUF and PM) in DMSO, with and without S9 metabolic activation	Induction of DNA damage (SOS) response (SOS chromotest)	Significant dose-related (m^3 equiv/assay) increase in DNA damage response for all pooled TSP/PUF samples without S9; 2 of 4 pooled $PM_{2.5}$/PUF samples elicited positive responses. With S9, responses marginal or negative	Škarek et al. (2007b)
Paris, France (1983–1985)	Airborne PM from an urban site, collected on GFFs with high-volume sampler. DCM or Ac sonication extraction	*Escherichia coli* PQ37, incubated for 2 h with 2 replicate extracts in DMSO, with and without S9 metabolic activation	Induction of DNA damage (SOS) response (SOS chromotest)	Significant dose-related (mg of EOM) increase in DNA damage response, without S9 only	Courtois et al. (1988)
Washington, DC, USA	Time-integrated (baghouse) urban PM collected in 1976 and 1977 (SRM 1649). DCM Soxhlet extraction	*Escherichia coli* PQ37, incubated for 2 h with 2 replicate extracts in DMSO, with and without S9 metabolic activation	Induction of DNA damage (SOS) response (SOS chromotest)	Some indication of SOS response induction both with and without S9. Erratic dose–response and high cytotoxicity with no clear, significant induction of DNA damage	Nylund et al. (1992)

Supplemental Table S17 (continued)

Geographical location	Test article	Assay/exposure system	End-point(s) examined	Results	Reference
Wrocław, Poland (2007)	PM_{10} from an urban site collected on sintered glass filters. DCM Soxhlet extraction	*Escherichia coli* PQ37, incubated for 2 h with 2 replicate extracts in DMSO, with and without S9 metabolic activation	Induction of DNA damage (SOS) response (SOS chromotest)	Significant dose-related (m^3 equiv) increase in DNA damage response, with and without S9. Elevated response without S9 in autumn (relative to summer)	Piekarska (2010)
Wrocław, Poland	Airborne PM from 2 urban sites, collected on glass filters. DCM Soxhlet extraction	*Escherichia coli* PQ37, incubated for 2 h with 2 replicate extracts in DMSO, with and without S9 metabolic activation	Induction of DNA damage (SOS) response (SOS chromotest)	Significant dose-related (m^3 equiv) increase in DNA damage response; higher with S9. Increased genotoxicity in winter compared with summer	Piekarska et al. (2011)
Taiyuan, China (1990)	Size-fractionated airborne PM from 2 urban sites. Extraction with nitric acid or SLF	*Escherichia coli* PQ35 and PQ37, incubated for 2 h with acid or SLF extracts	Induction of DNA damage (SOS) response (SOS chromotest)	Significant dose-related increase in DNA damage response for acid and SLF extracts for all size fractions. Increased induction of DNA damage response for extracts of smaller size fractions	Lei & Xing (1993), Lei et al. (1993)
Guangzhou, China (1991)	TSP, 12-month monitoring. DCM Soxhlet extraction	*Escherichia coli* PQ35 and PQ37, incubated for 2 h with extract in DMSO, without S9 metabolic activation	Induction of DNA damage (SOS) response (SOS chromotest)	Significant dose-related increase in DNA damage response for all samples; highest response observed in February and correlated with maximum TSP level. Sample potency affected by meteorological conditions	Qian et al. (1996)
Shanghai, China	TSP samples from 4 locations in industrial Baoshan district. DEE Soxhlet extraction	*Escherichia coli* PQ35 and PQ37, incubated for 2 h with extract in DMSO, without S9 metabolic activation	Induction of DNA damage (SOS) response (SOS chromotest)	Significant increase in DNA damage response for urban location; responses for residential/ suburban sites marginal or equivocal	Lu et al. (1997)
Montreal, Canada (1989)	Snow pack samples from 14 urban locations. DCM liquid–liquid extraction	*Escherichia coli* PQ35 and PQ37, incubated for 2 h with extract in DMSO, without S9 metabolic activation	Induction of DNA damage (SOS) response (SOS chromotest)	Only 1 sample elicited a positive response without S9; half the samples elicited a positive response with S9. Mean CO and NO_2 significantly higher at locations that yielded genotoxic samples. Significant association between sample potency and outdoor PM levels	White et al. (1995)

Supplemental Table S17 (continued)

Geographical location	Test article	Assay/exposure system	End-point(s) examined	Results	Reference
Netherlands	Airborne PM. MeOH sonication extraction	Differential survival of *Escherichia coli* 343/753 (*uvrB*/*recA*) and 343/765 (uvr^+/rec^+), exposed to PM extracts in vitro, with and without S9	Induction of DNA damage response	Significant dose-related (m^3 equiv/assay) induction of DNA damage response. Maximum response without S9	Heussen et al. (1990), Heussen & Alink (1990)
Houston, Texas, USA	Airborne TSP or size-fractionated PM, collected with high-volume sampler or cascade impactor. PM collected on GFFs. Soxhlet extraction with BZ:MeOH:DCM (1:1:1)	*Escherichia coli* UTH8177, overnight incubation with PM extracts	Induction of DNA damage response. Prophage induction assay (i.e. λ phage plaque counts)	No significant response despite strong response on *Salmonella* reverse mutation assay	Preidecker (1980a)
Several sites, urban Rio de Janeiro, Brazil, and Camden, New Jersey, USA	Airborne PM, collected on GFFs with cascade impactor. Sequential Soxhlet extraction with CX, DCM, and Ac	*Escherichia coli* $WP2_s\lambda^+$, overnight incubation with PM extracts	Induction of DNA damage response. Microscreen prophage induction assay (i.e. λ phage plaque counts)	Potency of most samples increased with S9, particularly Camden DCM extract. DCM extract for Rio de Janeiro greater than Ac and CX extracts. Similar potency for Camden and Rio samples.	Miguel et al. (1990)
Flanders, Belgium (2000)	PM_{10} from urban, rural, and industrial sites, collected on GFFs with low-volume sampler. ASE with THF/Hx (20:80)	*Salmonella typhimurium* TA104 recN2-4, incubation of log-phase cells with PM_{10} extract	Induction of DNA damage (i.e. SOS) response. Recorded as luminescence (Vitotox assay)	Significant induction of DNA damage response for 20 m^3 equiv/mL of urban site with S9. High cytotoxicity and no observable induction of DNA damage response for other samples	Brits et al. (2004)
Flanders, Belgium (2000–2001)	PM_{10} and SVOCs from urban, rural, and industrial sites; PM collected on quartz filters and SVOCs on PUFs with high-volume sampler. Ac Soxhlet extraction	*Salmonella typhimurium* TA104 recN2-4, incubation of log-phase cells with PM_{10} extract	Induction of DNA damage (i.e. SOS) response. Recorded as luminescence (Vitotox assay)	Significant induction of DNA damage response for PM extracts. Greater potency (per m^3) without S9, and higher potency in winter compared with summer. PUF extracts did not induce a positive response	Du Four et al. (2004)
Flanders, Belgium (2002)	PM_{10} and SVOCs from 15 urban, rural, and industrial sites; PM collected on quartz filters and SVOCs on PUFs with high-volume sampler. Ac Soxhlet extraction	*Salmonella typhimurium* TA104 recN2-4, incubation of cells with PM_{10} and PUF extract with and without S9	Induction of DNA damage (i.e. SOS) response. Recorded as luminescence (Vitotox assay)	Significant induction of DNA damage response for PM extracts. Greater potency (per m^3) without S9, and only 2 of 15 sites yielded positive samples with S9. Only 1 site yielded a PUF extract that elicited a significant positive response	Du Four et al. (2005)

Supplemental Table S17 (continued)

Geographical location	Test article	Assay/exposure system	End-point(s) examined	Results	Reference
Taiyuan, China (1991)	TSP samples from a residential area. Nitric acid or SLF sonication extraction	Exposure of human amnion cells for 5 h to acid or SLF extracts	Unscheduled DNA synthesis (incorporation of radio-labelled thymidine)	Significant dose-related increase in DNA damage for 0.5 m^3 equiv of acid extract and 21 m^3 equiv of SLF extract. Lead, zinc, chromium, manganese, and nickel suspected as contributors to DNA damage response	Yuan & Xun (1994)
Taiyuan, China (1987)	Size-fractionated TSP from a residential area. Nitric acid or SLF sonication extraction	Exposure of human amnion cells for 5 h to acid or SLF extracts	Unscheduled DNA synthesis (incorporation of radio-labelled thymidine)	Significant dose-related increase in DNA damage for all acid extracts. Significant DNA damage response for SLF extracts of PM < 2 µm only. Extracts of smaller size classes induced responses	Yuan et al. (1994)
Shanghai, China	TSP from 13 locations. NM sonication extraction	Exposure of primary hepatocytes from SD rats	Unscheduled DNA synthesis (incorporation of radio-labelled thymidine)	Significant dose-related increases in DNA damage response induced by most TSP extracts. Winter samples induced a stronger response relative to summer samples	Zhao & Zhu (1996)
Shanghai, China	TSP from 4 locations. NM sonication extraction; extract separated into 5 fractions	Exposure of primary hepatocytes from SD rats	Unscheduled DNA synthesis (incorporation of radio-labelled thymidine)	Significant dose-related increases in DNA damage induced by all fractions of all samples, except residential area during summer. Residential area induced the weakest response. Highest potency for PAH-containing fraction; in contrast, *Salmonella* potency highest for polar fraction	Zhao & Zhu (1997)
Leeds, United Kingdom	Size-fractionated PM from 3 urban sites in Leeds city centre, collected with cascade impactor. Water extraction	Incubation of plasmid DNA with PM extracts for 60 h	Plasmid DNA strand break assay	Significant induction of strand breaks; highest activity associated with smallest size fractions	Lingard et al. (2005)
Novara Province, Italy	In situ exposures at 19 sites, including urban, rural, and industrial locations	AFLPs in *Trifolium repens* L. after 6 wk exposure	DNA sequence changes measured as alterations in restriction sites	Significant increase in percentage of total polymorphisms at 4–7 sites, depending on season. Elevated ozone at locations with elevated polymorphisms	Piraino et al. (2006)

Ac, acetone; AFLP, amplified fragment length polymorphism; ASE, accelerated solvent extraction; 5,6-BF, 5,6-benzoflavone; BZ, benzene; CO, carbon monoxide; CX, cyclohexane; DCM, dichloromethane; DEE, diethyl ether; DMSO, dimethyl sulfoxide; EOM, extractable organic matter; equiv, equivalent; GFFs, glass-fibre filters; h, hour or hours; Hx, hexane; MeOH, methanol; NO_2, nitrogen dioxide; NR, nitroreductase; OAT, *O*-acetyltransferase; PAHs, polycyclic aromatic hydrocarbons; PB, phenobarbital; PM, particulate matter; PM_{10}, particulate matter with particles of aerodynamic diameter < 10 µm; $PM_{2.5}$, particulate matter with particles of aerodynamic diameter < 2.5 µm; PUF, polyurethane foam; SD, Sprague-Dawley; SLF, surrogate lung fluid; SRM, standard reference mixture; SVOCs, semivolatile organic compounds; THF, tetrahydrofuran; TSP, total suspended particles; wk, week or weeks.

Supplemental Table S18 Changes in gene expression in experimental animals associated with exposure to polluted outdoor air

Animals	Exposure	Assay	Results	Call	Reference
Male SD rats	Intratracheal installation of PM_{10} from Cardiff, United Kingdom, for 3 d	Lung RNA evaluated with Atlas Rat 1.2 macroarrays	Altered expression of genes coding for hormone receptors, growth factors, cytokines, IL-2, chemokines, and ligand-gated ion channels	+	Wise et al. (2006)
Male hypertensive rats	Intratracheal installation of EHC-93 urban particulate for 2–20 h	Lung RNA evaluated with Affymetrix U34A	Altered expression of genes in the oxidative stress, inflammation, transcriptional regulation, and cardiovascular system pathways	+	Kooter et al. (2005)
Female BALB/cJ mice	Inhalation exposure to 380 μg/m³ for 4 h and 24 h of ultrafine carbon particles generated by an electric spark motor	Lung RNA evaluated with Affymetrix U74Av2 GeneChip	Increased expression of heat shock genes after 4 h, but increased expression of other immunomodulatory proteins after 24 h of inhalation exposure	+	André et al. (2006)
Male C57BL/6 mice	Inhalation exposure to < 2.5 μm CAPs from an urban area near San Joaquin Valley, California, USA, for 6 h/d, 5 d/wk, for 2 wk. Winter CAPs, 39.01 μg/m³; summer CAPs, 21.7 μg/m³	Lung RNA evaluated by qRT-PCR (TaqMan, Applied Biosystems)	Winter CAPs increased expression of *IL-2*, *MIP-1α*, *TNFα*, *CYP1a1*, *ICAM-1*, and *Nox-2*	+	Tablin et al. (2012)
Male C57BL6 mice	Inhalation exposure in Craeybeckx tunnel in Antwerp, Belgium, for 5 d; 55.1 μg/m³ of $PM_{2.5}$; EC = 13.9 μg/m³	Olfactory bulb and hippocampus tissue from brain evaluated by RT-PCR	Increased expression of inflammatory response (*COX2*, *NOS2*, *NOS3*, and *NFE2L2*) in the hippocampus, and decreased expression of *IL-1α*, *COX2*, *NFE2L2*, *IL-6*, and *BDNF* in the olfactory bulb	+	Bos et al. (2012)
Male Brown Norway rats	Rats first given ovalbumin by intranasal installation for 3 d, then exposed to 1–2.5 μm CAPs from Grand Rapids, Michigan, USA, for 8 h/d for 13 d at 493 μg/m³	Lung RNA evaluated with Affymetrix R230 2.0 whole-genome arrays	Altered expression of genes in the inflammation and immune-response pathways	+	Heidenfelder et al. (2009)
Male C57BL/CBA mice	Inhalation exposure in situ near a busy highway and 2 steel mills in Hamilton, Ontario, Canada	Lung RNA evaluated with Agilent G4121B microarrays	Altered expression of genes in lipid droplet synthesis and antioxidant defence	+	Rowan-Carroll et al. (2013)
Male F344 rats	Inhalation exposure for 5 h/d, 4 d/wk, up to 10 months to CAPs from Riverside, California, USA. Mass (μg/m³) was 63 (UFP), 149 (FP), and 58 (CP)	Brain RNA evaluated with Affymetrix GeneChip Rat Genome 230 microarray	Increased expression of *Arc* up to 3-month exposure to CP, then decreased. Increased expression of *Rac1* after 10-month exposure to CP	+	Ljubimova et al. (2013)
Male C57Bl/6 mice	Inhalation exposure to $PM_{2.5}$ CAPs from unspecified urban area for 8 h/d for 9 wk	Lung RNA evaluated by RT-PCR	Increased expression of *DNMT1*	+	Soberanes et al. (2012)
Male C57BL/6 mice	Inhalation exposure to $PM_{2.5}$ CAPs from Columbus, Ohio, USA, for 6 h/d, 5 d/wk, for 10 months	RNA from epididymal mouse adipose tissues evaluated by RT-PCR	Increased *ERAD* and *RIDD*	+	Mendez et al. (2013)

CAPs, concentrated ambient particles; CP, coarse particles; d, day or days; FP, fine particles; h, hour; IL-2, interleukin-2; PCR, polymerase chain reaction; PM_{10}, particulate matter with particles of aerodynamic diameter < 10 μm; $PM_{2.5}$, particulate matter with particles of aerodynamic diameter < 2.5 μm; SD, Sprague-Dawley; UFP, ultrafine particles; wk, week.

Supplemental Table S19 Changes in gene expression in vitro induced by polluted outdoor air

Cells	Exposure	Assay	Results	Call	Reference
Human breast cancer cell line MCF7	Extract of urban dust particulate SRM 1649a + B[*a*]P	Affymetrix U133A GeneChip arrays	Increased expression of *CYP1A1* and *CYP1B1*, as well as genes in DNA repair, tissue growth factor, and oncogene pathways	+	Mahadevan et al. (2005)
Primary mouse alveolar type II cells	$PM_{2.5}$ NIST SRM 1649 standard	RT-qPCR	Increased *DNMT1*	+	Soberanes et al. (2012)
Human lung epithelial cell line L132	$PM_{2.5}$ from Dunkirk, France	RT-qPCR	Increased apoptosis genes: *TNFα*, *caspase-3*, *-8*, *-9*	+	Dagher et al. (2006)
Human lung cell line A549	$PM_{2.5}$ from Dunkirk, France	RT-qPCR	Increased *CYP1A1*, *CYP2E1*, *CYP2F1*, *NQO1*, and *GST-π1*	+	Billet et al. (2007)
Human AMs	$PM_{2.5}$ from Dunkirk, France	RT-qPCR	Increased *CYP1A1*, *CYP2E1*, *NQO1*, and *GST-π1/μ3*	+	Saint-Georges et al. (2008)
Human AMs and human lung cell line L132	$PM_{2.5}$ from Dunkirk, France	RT-qPCR	In AMs, AMs co-cultured with L132 cells, and L132 cells, PM increased expression of *CYP1A1*, *CYP2E1*, *NQO1*, *GST-π1*, and/or *GST-μ3*. In L132 cells co-cultured with AMs, no changes in gene expression	+ –	Abbas et al. (2009)
Human lung cell line BEAS-2B	$PM_{2.5–3.0}$ from Dunkirk, France	RT-qPCR	Increased *CYP1A1*, *CYP1B1*, *IL-6*, and *IL-8*	+	Dergham et al. (2012)
Human monocyte-macrophage line U937	PM_{10} from Rome, Italy (direct exposure)	Clontech Atlas Human Toxicology 1,2 cDNA Expression Array	Changes in 87 of 1176 genes; 9 were associated with lung cancer. Increased DNA repair and apoptosis genes, such as *ERCC1*, *TDG*, *DAD1*, and *MCL1*	+	Bastonini et al. (2011)
Human airway epithelial cells	Coarse, fine, and ultrafine PM from Chapel Hill, North Carolina, US	Affymetrix HGU133A microarray	Changes in expression of NRF2-mediated oxidative-stress response genes, cell-cycle genes, DNA damage checkpoint genes, and polo kinase genes	+	Huang et al. (2011)
Human lung cell line HEL12469	EOM from $PM_{2.5}$ from 4 cities in Czech Republic	Illumina Human-HT12v3 Expression Bead Chips	Increased *CYP1B1*; decreased *ABC Transporters*, *Wnt*, *TGF-β*, steroid biosynthesis, glycerolipid metabolism	+	Líbalová et al. (2012)
Normal human tracheobronchial epithelium 3-D cell constructs	PM from Swansea, United Kingdom	RT-PCR and Biorad Human Stress and Toxicity Pathway Finder PCR Array	Increased *CYP1A1*; decreased *MT2A*, *NFKB1*, *RAD50*, *UNG*, *ANXA5*, *BCL2L1*, *MUC1*, and heat shock genes	+	Hoogendoorn et al. (2012)

AMs, alveolar macrophages; B[*a*]P, benzo[*a*]pyrene; EOM, extractable organic matter; PCR, polymerase chain reaction; PM, particulate matter; PM_{10}, particulate matter with particles of aerodynamic diameter < 10 μm; $PM_{2.5}$, particulate matter with particles of aerodynamic diameter < 2.5 μm; STM, standard reference mixture.

Supplemental Table S20 Lung inflammation in animals after exposure to air pollution particles

Particles	Species	Extraction	Exposure time and dose	Effect	Reference
Inhalation of CAPs from Bilthoven, Netherlands	Spontaneously hypertensive rats and ozone-pre-exposed rats	NA	1.2 mg/m³ for 6 h, and killed 2 d later	Increased PMNs in BALF. Unaltered levels of IL-6, MIP2, and TNF	Cassee et al. (2005)
Inhalation of CAPs from Boston, Massachusetts, USA	SD rats (normal or SO_2-pre-treated rats)	NA	500 μg/m³, 5 h/d for 3 consecutive days, and killed at 24 h after the last exposure	Increased number of PMNs in BALF	Clarke et al. (1999)
Inhalation of CAPs from Boston, Massachusetts, USA	Young and old F344 rats	NA	100 μg/m³, 5 h/d for 3 consecutive days, and killed at 24 h after the last exposure	Substantially higher pulmonary inflammation (total cells and PMNs in young compared with old rats)	Clarke et al. (2000a)
Inhalation of CAPs from Boston, Massachusetts, USA	Dogs	NA	200 μg/m³, 6 h/d for 3 consecutive days, and killed at 24 h after the last exposure	Statistically non-significant percentage of PMNs in BALF	Clarke et al. (2000b)
Inhalation of CAPs from Tuxedo, New York, USA	Rats	NA	110–350 μg/m³ for 3 h, and killed after 3 h or 24 h	Increased number of neutrophils in BALF after 3 h, but not 24 h	Gordon et al. (1998)
Inhalation of CAPs from Boston, Massachusetts, USA, by inhalation	SD rats	NA	1.1 mg/m³ for 5 h, and killed at 24 h after the exposure	Increased levels of PMNs in BALF. NAC pre-treatment inhibited pulmonary inflammation	Rhoden et al. (2004)
Inhalation of CAPs from Boston, Massachusetts, USA	SD rats (normal or pre-exposed to SO_2 to develop chronic bronchitis)	NA	255 μg/m³, 5 h/d for 3 consecutive days, and killed at 24 h after the last exposure	Increased inflammation (PMNs) in both the normal and chronic bronchitis rats	Saldiva et al. (2002)
Inhalation of CAPs from Manhattan, New York, USA	C3H and C57/BL6 mice	NA	300 μg/m³ for 6 h, and killed at 24 h after the exposure	Increased expression of *IL-6*, *TNF*, *TGF*, *IFN-γ*, and *MIF* in lung tissue	Shukla et al. (2000)
Inhalation of PM from Porto Alegre, Brazil	Wistar rats	NA	110–140 μg/m³ for 6, 20, or 4 × 5 h, and killed at 24 h after the exposure	Increased number of leukocytes in BALF of rats exposed for 20 h, and unaltered response in rats after 6 h. Intermittent (4 × 5 h on 4 d) did not generate inflammation	Pereira et al. (2007)
Inhalation of CAPs from Grand Rapids, Michigan, USA	Brown Norway rats	NA	493 μg/m³, 8 h/d for 13 d, and killed 24 h after the last exposure	Unaltered total or differential cell count (including PMNs) in BALF	Heidenfelder et al. (2009)
Inhalation of CAPs from Chapel Hill, North Carolina, USA, or ROFA	SD rats with or without bronchitis	NA	475–907 μg/m³ (or 1 mg/m³ for ROFA), 6 h/d for 2–3 d, and killed immediately after the last exposure	Unaltered total or neutrophils in BALF of healthy rats, whereas rats with bronchitis had increased influx of neutrophils after exposure to CAPs and ROFA	Kodavanti et al. (2000)

Supplemental Table S20 (continued)

Particles	Species	Extraction	Exposure time and dose	Effect	Reference
Inhalation of CAPs from a city background location in Bilthoven and a freeway tunnel, Netherlands	Spontaneously hypertensive rats	NA	399–3612 µg/m³, 6 h/d for 2 d, and killed 18 h after the last exposure	Unaltered cell count, MIP2, and TNF in BALF	Kooter et al. (2006)
Inhalation of EHC93	F344 rats	NA	57 µg/m³ for 4 h, and killed 33 h later	Increased number of neutrophils in air space and tissue	Adamson et al. (1999b)
Inhalation or intratracheal instillation of ROFA	SD rats	Saline	12 mg/m³ for 6 h or 110 µg/rat for 24–94 h	Highest level of neutrophils in BALF at 24 h. Same level of inflammation by intratracheal instillation and inhalation	Costa et al. (2006)
Intratracheal instillation of EHC93	Spontaneously hypertensive rats	Saline	10 mg/kg, and killed at 4 h or 24 h	Increased percentage of PMNs in BALF	Bagate et al. (2004)
Intratracheal instillation of PM from a motorway tunnel or EHC93	Spontaneously hypertensive rats	Water, ethanol, and methanol (sonication)	3 mg/kg or 10 mg/kg	Dose-dependent increase in the number of neutrophils in BALF at 24 h (lower levels at 48 h). Increased levels of IL-6, TNF, and MIP2 in BALF (protein)	Gerlofs-Nijland et al. (2005)
Intratracheal instillation of EHC93	Wistar rats	NA	5 mg/rat, and killed at day 2–7 after the exposure	Increased number of cells in BALF at day 2, with decreased levels at day 4 and 7 after exposure. Increased expression of *MIP2*, *TNF*, and *Inos*	Ulrich et al. (2002)
Intratracheal instillation of EHC93	Swiss mice	NA	1 mg/mouse, and killed at 72 h–8 wk	Increased PMNs in BALF. Water-soluble fraction more inflammogenic than insoluble fraction. Inflammogenicity was mainly explained by the content of zinc	Adamson et al. (1999a, 2000)
ROFA	CD1 mice and transgenic mice overexpressing SOD	NA	50 µg/mouse, and killed at 24 h	Higher levels of PMNs, TNF, and MIP2 in BALF from CD1 mice compared with mice with overexpression of SOD	Ghio et al. (2002)
Intratracheal instillation of SRM 1648	C57BL/6	PBS	1.6 mg/lung, and killed at 20 h	Increased content of IL-6, TNF, and MIP2 in BALF (protein)	Becher et al. (2007)
Intratracheal instillation of fine and coarse particles from 4 cities in Europe, collected in different seasons, and EHC93	Wistar rats	Saline (stirring)	2.5 mg/rat, and killed at 24 h	Fine particles more potent than coarse particles. Influx of neutrophils associated with season. TNF and MIP2 responses dependent on both city and season	Halatek et al. (2011)

Supplemental Table S20 (continued)

Particles	Species	Extraction	Exposure time and dose	Effect	Reference
Fine and coarse particles from cities in Europe	Spontaneously hypertensive rats	Saline	3 or 10 mg/kg, and killed at 24 h	Increased cell count, TNF, and MIP2 in BALF. Tendency towards a more pronounced inflammation response by coarse particles than fine particles. Tendency that particles from sites with high intensity of traffic were most inflammogenic	Gerlofs-Nijland et al. (2007)
Intratracheal instillation of coarse, fine, and ultrafine particles from 6 different cities in Europe	C57B1/6J mice	Methanol	1–10 mg/kg for 4, 12, or 24 h	Dose-dependent increase for coarse particles, which showed stronger effect compared with fine and ultrafine particles on mass basis. Same tendency for TNF, IL-6, and KC in BALF	Happo et al. (2007)
Intratracheal aerosolization of PM_{10} or $PM_{2.5}$ from Milan, Italy, collected during summer or winter at a heavy-traffic site	Balb/c mice	Water (sonication)	100 µg/mouse, and killed at 3 h, 24 h, or 1 wk	PM_{10} samples slightly more potent than $PM_{2.5}$ samples, and winter samples slightly more potent than summer samples (percentage of PMNs at 24 h). $PM_{2.5}$ from summer most potent at 3 h and unaltered effect at 1 wk. TNF (3 h) highest for PM_{10}, and summer samples more potent than winter samples	Farina et al. (2011)
Fine and coarse particles from Duisburg (industrial area) and Borken (rural area) in Germany	Wistar rats	Water (sonication)	0.32 mg/rat, and killed at 18 h	Coarse particles increased number of neutrophils in BALF. Only coarse particles from Borken increased level of TNF and MIP2 in BALF. Strong association between inflammatory response and endotoxin level	Schins et al. (2004)
Intratracheal instillation of $PM_{2.5}$ or PM_{10} from locations near to or far away from traffic in Beijing, China	Wistar rats	Water (sonication)	7.5 mg/kg once/d for 14 d, and killed at 24 h after the last instillation	Higher levels of TNF, IL-6, and IL-1 (protein) in lung homogenate $PM_{2.5}$ generated higher levels of inflammation than PM_{10}. Particles collected closest to traffic generated highest levels of inflammation	Zhang et al. (2011)
Dust storm particles from Shapotou, China, or Arizona, USA	ICR mice	Saline	0.1 mg/mouse 4 times over 8 wk, and killed at 24 h after the last exposure	Increased number of cells in BALF (predominantly macrophages). Increased TNF and IFN-γ (protein); unaltered levels of IL-5, IL-6, IL-12, and IL-13 in BALF	Ichinose et al. (2008)
Fine particles from World Trade Center dust, Mt Saint Helens dust, ROFA, and SRM 1649 by oropharyngeal aspiration	CD-1 mice	Water	32–100 µg/mouse, and killed at 24 h	Increased neutrophils in BALF by fine particles. ROFA (and SRM 1649) more potent than World Trade Center fine particles	Gavett et al. (2003)
Intratracheal instillation of ROFA	SD rats	Saline	500 µg/rat, and killed at 3 h or 24 h	Increased number of neutrophils in BALF (24 h) and IL-6, TNF, CCL2, and IL-1β (3 h) gene expression, whereas MIP2 was unaltered	Roberts et al. (2003)

Supplemental Table S20 (continued)

Particles	Species	Extraction	Exposure time and dose	Effect	Reference
Intranasal instillation of PM from a heavy-traffic location in Buenos Aires, Argentina, or ROFA	Balb/c mice	PBS (sonication)	0.17 mg/kg 3 times/d on days 1, 4, and 7, and killed 1 h after the last exposure	Increased pulmonary inflammation (histology and neutrophils in BALF)	Martin et al. (2007), Martin et al. (2010)
Intranasal instillation of $PM_{2.5}$ from São Paulo, Brazil	Balb/c mice	Water (sonication)	5–15 µg/mouse, and killed at 24 h	Increased number of neutrophils, macrophages, IL-6, and TNF in lung tissue sections	Riva et al. (2011)
Intranasal instillation of CAPs from Boston, Massachusetts, USA	Balb/c mice with or without IFN-γ pre-treatment	Saline (sonication)	50 µg/mouse, and killed at 24 h	Increased number of PMNs in BALF. Macrophages and PMNs had increased ex vivo production of ROS (DCFH assay)	Sigaud et al. (2007)
Intratracheal instillation of aqueous extract or insoluble fraction of TSP from Provo, Utah, USA	SD rats	Water (agitation)	100–1000 µg/rat, and killed 24 h after the exposure	Dose-dependent increase in neutrophils in BALF. Lower response with soluble fraction compared with insoluble fraction	Ghio et al. (1999)
Intratracheal instillation of coarse, fine, and ultrafine particles from Chapel Hill, North Carolina, USA	CD-1 mice	Collected on an electrostatic precipitator	10–100 µg/mouse, and killed at 18 h	Increased influx of neutrophils (dose-dependent for fine and ultrafine particles). Increased levels of TNF and IL-6 in BALF. Decreased inflammation by treatment with DMTU	Dick et al. (2003)

BALF, bronchoalveolar lavage fluid; CAPs, concentrated ambient particles; d, day or days; DCFH, 2′,7′-dichlorodihydrofluorescein; DMTU, dimethylthiourea; h, hour or hours; IFN-γ, interferon-gamma; IL-6, interleukin-6; NA, not applicable; NAC, *N*-acetylcysteine; PBS, phosphate-buffered saline; PM, particulate matter; PM_{10}, particulate matter with particles of aerodynamic diameter < 10 µm; $PM_{2.5}$, particulate matter with particles of aerodynamic diameter < 2.5 µm; PMNs, polymorphonuclear leukocytes; ROFA, residual oil fly ash; ROS, reactive oxygen species; SD, Sprague-Dawley; SRM, standard reference mixture; TNF, tumour necrosis factor; wk, week or weeks.

Supplemental Table S21 Markers of inflammation in cultured cells exposed to air pollution particles

Particles	Cells	Extraction	Exposure conditions	Effect	Reference
$PM_{2.5}$ from Porte d'Auteuil, France	Human nasal epithelial cells	Water (sonication)	10–80 μg/cm² for 24 h	Concentration-dependent increase in release of GM-CSF, IL-6, and IL-8. Weak and inconsistent increase in TNF (protein)	Auger et al. (2006)
$PM_{2.5}$ from a school playground in Vitry-sur-Seine, France, or SRM 1648	Human bronchial epithelial cells (16-HBE)	Sonication	10–30 μg/cm² for 4 h	Concentration-dependent increase in release of GM-CSF (protein)	Baulig et al. (2003)
SRM 1648	Alveolar type 2 cells or macrophages	NA	20 μg/cm² (or 200 μg/mL) for 20 h	Increased release of IL-6 and MIP2 (protein)	Becher et al. (2007)
PM_{10} from a street in London, United Kingdom	J774 macrophages	PBS (vortexing)	5–100 μg/mL for 4 h	Concentration-dependent increase in TNF secretion (protein)	Brown et al. (2004)
PM_{10} from a street in London, United Kingdom	Mononuclear blood cells	PBS (vortexing)	10 μg/mL for 4 h	Increased TNF (protein) secretion	Brown et al. (2007)
EHC93	Human alveolar and bronchial epithelial cells	NA	100 μg/mL for 24 h	Increased secretion of GM-CSF, IL-6, IL-8, IL-1β, and TNF (protein and mRNA) in macrophages, whereas there was less effect in bronchial epithelial cells	Fujii et al. (2001, 2002)
PM from Dunkirk, France	L132	Mechanical collection from plates	19 μg/mL and 75 μg/mL for 24–72 h	Increased TNF (protein), iNOS activity, and NO production (Griess)	Garçon et al. (2006)
$PM_{2.5}$ from Helsinki, Finland, EHC93, or SRM 1649	RAW 264.7	Methanol or water (sonication)	150 μg/mL for 12 h or 24 h	EHC93 was more inflammogenic than SRM 1649. $PM_{2.5}$ was the least inflammogenic based on TNF, IL-1, IL-6 (protein), and NO (Griess). Water and methanol extraction generated the same effect	Jalava et al. (2005)
PM_{10} from a busy street in Stockholm, Sweden.	A549	Water (sonication)	40 μg/cm² for 4 h	Increased levels of IL-6, IL-8, and TNF (protein)	Karlsson et al. (2006)
SRM 1648	RAW 264.7	NA	62.5 μg/cm² for 4 h	Increased PGE_2 release (protein)	Schneider et al. (2005)
SRM 1649	Mouse macrophages and Kupffer cells	NA	100 μg/mL or 200 μg/mL for 24 h	Concentration-dependent increases in IL-6 (protein). Also increased mRNA of IL-6, TNF, and IL-12	Tan et al. (2009)
EHC93 or ROFA	AMs	NA	0.01–0.1 mg/mL for 24 h	Concentration-dependent TNF response by EHC93. ROFA less potent than EHC93. Also increased cytokine profile by EHC93 (increased IL-8, IL-6, GM-CSF, MIP-1a, MIP-1b, IL-1α, IL-1β, IL-10, and TNF)	van Eeden et al. (2001)
$PM_{2.5}$ from Cache Valley, Utah, USA	BEAS-2B	Water (sonication)	0.8–3.9 μg/mL for 24 h	Increased IL-6 excretion (protein). Excretion of TNF was unaltered	Watterson et al. (2007)

Supplemental Table S21 (continued)

Particles	Cells	Extraction	Exposure conditions	Effect	Reference
SRM 1649 or ROFA	RLE, AMs, or co-culture	NA	1–50 μg/mL for 24 h	Unaltered secretion of MIP2 and TNF in mono-cultures, whereas there were concentration-dependent increases in co-cultures	Tao & Kobzik (2002)
PM_{10}, $PM_{2.5}$, PM_{1}, and $PM_{0.4}$ from Milan, Italy, collected during summer or winter	THP-1 or THP-1/A549 co-cultures	Water (sonication)	10 μg/cm² for 24 h	Increased IL-6 and IL-1β secretion (protein) in THP-1 or co-cultures (and IL-8 in co-cultures) exposed to PM_{10} collected during summer (correlated with endotoxin level)	Longhin et al. (2013)
Fine and coarse fraction of PM from 4 cities in Europe	Rat lung type 2 cells and AMs	Methanol	10–50 mg/mL for 24 h	Increased MIP2, IL-6, and TNF (protein) with both spatial and temporal variability. Coarse fraction more potent than fine fraction	Dybing et al. (2004), Hetland et al. (2005)
Coarse, fine, and ultrafine particles from 6 cities in Europe	RAW 264.7	Methanol (sonication)	15–300 μg/mL for 24 h	Concentration-dependent increases in NO (Griess), TNF, IL-6, and MIP2 (protein). Coarse particles more potent than fine and ultrafine particles. Inter-city variability in inflammation potency	Jalava et al. (2007)
$PM_{2.5}$ from rural and urban (Dakar city) sites in Senegal	BEAS-2B	Mechanically recovered	3–12 μg/mL for 24–48 h	Increased TNF, IL-8, and IL-6, and unaltered IL-1β secretion. Increased IL-1β, IL-6, and IL-8 mRNA levels, and unaltered TNF. Urban sites more potent than rural site	Dieme et al.(2012)
PM_{10} from different locations in Mexico City, Mexico	J774A.1 and RLE	Mechanically recovered	40–80 μg/cm² for 24 h	Concentration-dependent increases in IL-6 and TNF (protein) in J774A.1 cells and PGE_2 secretion by RLE cells. Particles from one location (business area) more potent than those from other areas (industry or residential areas)	Alfaro-Moreno et al.(2002)
$PM_{2.5}$ collected at a busy street or urban background in Copenhagen, Denmark	A549	Water	25 μg/mL for 24 h	Increased expression level of IL-6 and IL-8, although not a clear difference between street and background particles	Sharma et al.(2007)
PM from a town with many wood stoves and a rural area, Denmark	A549 and THP-1	Mechanical collection from plates	2.5–100 μg/mL for 3 h	Unaltered expression of CCL2, I-L8, and IL-6 (mRNA) in A549 cells. Increased expression levels of CCL2, IL-8, and TNF (mRNA) in THP-1 cells	Danielsen et al.(2011)
PM_{10} from Utah Valley, Utah, USA	BEAS-2B	Water (agitation)	125–500 μg/mL for 2 h or 24 h	Concentration-dependent increase in IL-6 and IL-8 (protein or protein) production. Lowest potency had samples that were collected during a strike at the steel mill in the area	Frampton et al.(1999)
PM from a street tunnel in Oslo, Norway	THP-1	Scraping off the filter	20–280 μg/mL for 12 h	Increased TNF, IL-1β, and IL-8 (protein) secretion. Undetectable levels of IL-4, IL-6, and IL-10. No difference between particles collected in seasons with or without use of studded tyres	Kocbach et al.(2008)

Supplemental Table S21 (continued)

Particles	Cells	Extraction	Exposure conditions	Effect	Reference
Water-soluble fraction of PM_{10} from cities in Switzerland	Rat AMs (NR8383)	Water (shaking)	Concentration not reported. Incubation for 40 h	Highest potency of particles collected during summer and autumn compared with other seasons	Monn et al. (2003)
PM_{10} from Helsinki, Finland, collected during spring or winter	RAW 264.7	Methanol (sonication)	15–1000 μg/mL for 24 h	Increased TNF, IL-6 production (protein), and NO (Griess). Particle fraction had stronger response than water-soluble fraction. No effect of DFO treatment. Spring samples more potent than winter samples	Salonen et al. (2004)
Outdoor and indoor $PM_{2.5}$ samples from Boston, Massachusetts, USA, or SRM 1649	Rat AMs	Water (sonication)	100 μg/mL for 20 h	Indoor samples more potent than outdoor samples in TNF secretion (protein) after normalization for endotoxin content	Long et al. (2001)
PM from Chapel Hill, North Carolina, USA, and ROFA	Bronchial epithelial cells and AMs	Water (sonication)	11 $\mu g/m^3$ or 50 $\mu g/m^3$ for 18 h	Increased IL-6 and IL-8 release (protein). Coarse particles more potent than fine and ultrafine particles. Low temporal variability in cytokine secretion	Becker et al. (2005)
Fine and coarse particles from Chapel Hill, North Carolina, USA, SRM 1649, volcanic ash, or Mount St Helens dust	Human AMs	Water (sonication)	50–100 μg/mL for 24 h	SRM 1649 increased the production of TNF, IL-6, and IL-8. Fine and coarse particles increased TNF and IL-8, with a tendency to be size- and season-dependent	Sawyer et al. (2010)
Fine and coarse particles from Duisburg (industrial area) and Borken (rural area), Germany	WBCs	Water (sonication)	< 0.7 mg/mL for 4 h	Coarse particles generated more IL-8 and TNF than fine particles. Particles from Borken were most inflammogenic. Inflammogenicity correlated with endotoxin content in sample	Schins et al. (2004)
Coarse, fine, and ultrafine samples from the Netherlands	RAW 264.7	VACES	6.3–100 μg/mL for 16 h	Increased secretion of TNF, IL-6, and MIP2. Fine particles more inflammogenic than ultrafine particles (coarse particles were not included because of high endotoxin content)	Steenhof et al. (2011)
Coarse, fine, or ultrafine particles from Tuxedo, New York, USA, or SRM 1649	HMCEC-LB1	Water (outdoor air particles)	25–200 mg/mL for 24 h	Concentration-dependent increases in IL-6 secretion (protein). Decreased IL-6 production of fine particles by DFO pre-treatment	Qu et al. (2010)
PM in different size fractions from urban and rural sites, United Kingdom	A549	Water (sonication)	100 $\mu g/cm^2$ for 24 h	Increased IL-8 release, with some dependency on locations and particle sizes	Wessels et al. (2010)
Aqueous extract or insoluble fraction of TSP from North Provo, Utah, USA	BEAS-2B	Water (agitation)	500 μg for 24 h	Increased IL-8 release (protein). Higher response for soluble extract compared with insoluble fraction	Ghio et al. (1999)

Supplemental Table S21 (continued)

Particles	Cells	Extraction	Exposure conditions	Effect	Reference
$PM_{2.5}$ from Toronto, Canada, or SRM 1648	A549	Water	10–1000 µg/mL for 24 h	Water-insoluble content of SRM 1648 more potent than water-soluble content for IL-8 secretion (protein). Only increased IL-8 secretion at high concentration of $PM_{2.5}$ samples	Akhtar et al. (2010)
SRM 1649, ROFA, or CAPs from Boston, Massachusetts, USA	AMs (LPS-primed)	Saline (sonication) for CAPs	25–100 µg/mL for 20 h	Substantial difference in potency to promote TNF secretion by CAPs collected on different days. TNF secretion was attributed mainly to the particle fraction, whereas the water-soluble fraction had little effect	Imrich et al. (1999)
ROFA	Bronchial epithelial cells	NA	5–200 µg/mL for 2 h or 24 h	Concentration-dependent increase in IL-6, IL-8, and TNF (protein and mRNA). Decreased cytokine secretion by treatment with DFO or DMTU	Carter et al. (1997)
ROFA	RAW 264.7 and hamster AMs	Saline (sonication)	100–400 µg/mL for 0.5 h and 16 h	Concentration-dependent increase in TNF production (protein), which was inhibited by DFO. *MIP2* gene expression increased after 30-minute exposure	Goldsmith et al. (1998)
SRM 1649 or CAPs from Boston, Massachusetts, USA	AMs (LPS-primed)	Water (sonication)	100 µg/mL for 20 h	Increased TNF release (protein), which was diminished by treatment with NAC, catalase, or DMTU	Imrich et al. (2007)
PM_{10} from an urban street in Stockholm, Sweden	RAW 264.7	Water (sonication)	1–100 µg/mL for 18 h	Concentration-dependent increase in IL-6 and TNF (protein), which was inhibited by DFO or NAC. Increased NO release. Increased mRNA expression of *IL-6* and *iNOS* (non-significant for TNF)	Lindbom et al. (2007)
$PM_{2.5}$ from Vermont, USA	Murine alveolar type 2 cells	Water and sonication	10 µg/cm^2 for 1–8 h	Increased NFκB binding to DNA, which was ameliorated by pre-treatment with catalase, but not DFO	Shukla et al. (2000)
PM from Düsseldorf, SRM 1648, EHC93, volcanic and oil fly ash	Human or rat alveolar cells	Not specified	18.5–500 µg/mL for 18–20 h	Increased TNP and IL-6 secretion (protein) by EHC93, PM from Düsseldorf, and SRM 1648. Unaltered secretion by volcanic and oil fly ash. DFO pre-treatment had no effect on SRM 1648-mediated IL-6 secretion	Becker et al. (1996)
EOM of coarse and fine particles from Paso del Norte Air Basin, Texas, USA	BEAS-2B	DCM	50 µg/mL for 18 h	Unaltered gene expression of IL-6 and IL-8	Lauer et al. (2009)
EOM of road tunnel particles from Shanghai, China	A549	DCM (sonication)	1–400 µg/mL for 24 h	Bell-shaped concentration effect curve with increased gene expression of *IL-6* and *IL-8* (mRNA). Unaltered expression of *CCL2* and *RANTES*	Shang et al. (2013)

AMs, alveolar macrophages; CAPs, concentrated ambient particles; DCM, dichloromethane; DFO, deferoxamine; DMTU, dimethylthiourea; EOM, extractable organic matter; GM-CSF, granulocyte macrophage colony-stimulating factor; h, hour or hours; IL-6, interleukin-6; NA, not applicable; NAC, *N*-acetylcysteine; PBS, phosphate-buffered saline; PGE_2, prostaglandin E2; PM, particulate matter; PM_{10}, particulate matter with particles of aerodynamic diameter < 10 µm; $PM_{2.5}$, particulate matter with particles of aerodynamic diameter < 2.5 µm; ROFA, residual oil fly ash; SRM, standard reference mixture; TNF, tumour necrosis factor; VACES, versatile aerosol concentration enrichment system; WBCs, white blood cells; wk, week or weeks.

Supplemental Table S22 Production of reactive oxygen species in cells exposed to air pollution particles

Particles	Cells	Extraction	Exposure conditions	Effect	Reference
$PM_{2.5}$ from Porte d'Auteuil, France	Human nasal epithelial cells	Water (sonication)	10–80 μg/cm² for 3 h	Increased ROS production (DCFH)	Auger et al. (2006)
$PM_{2.5}$ from Vitry-sur-Seine, France, or SRM 1648	Human bronchial epithelial cells (16-HBE)	Sonication	10 μg/cm² for 4 h	Increased ROS production (DCFH)	Baulig et al. (2003)
PM from Düsseldorf, SRM 1648, EHC93, volcanic and oil fly ash	Human or rat alveolar cells	Not specified	18.5–500 μg/mL for 0.5 h	Increased ROS production (luminol and chemiluminescence) by all particles. Oil fly ash particles more potent than other particles	Becker et al. (1996)
PM from Chapel Hill, North Carolina, USA, and ROFA	Bronchial epithelial cells and AMs	Water (sonication)	11 or 50 μg/m³ for 1 h	Increased ROS production (DCFH and DHR). Coarse, fine, and ultrafine particles generated the same level of ROS on mass basis. High temporal variability in ROS production	Becker et al. (2005)
PM from a town with many wood stoves and a rural area, Denmark	A549 and THP-1	Water	2.5–100 μg/mL for 3 h	Concentration-dependent increase in ROS production (DCFH)	Danielsen et al. (2010)
ROFA and CAPs from Boston, Massachusetts, USA	Hamster AMs	Water (sonication)	25–200 μg/mL and 4–20 μg/mL for 0.5 h	Concentration-dependent increase in ROS production (DCFH). ROFA had a stronger effect than CAPs	Goldsmith et al. (1997)
Airborne PM from Düsseldorf, Germany	Human bronchial epithelial cells (IB3–1 and S-9 CF)	Baghouse	25 μg/cm² for 1 h	Increased ROS production (DCFH)	Kamdar et al. (2008)
PM_{10} from a busy street in Stockholm, Sweden	A549	Water (sonication)	20 μg/cm² for 2 h	Increased ROS production (DCFH)	Karlsson et al. (2008)
PM from Osaka, Japan	Human mononuclear blood cells	Aqueous solution	50–650 μg/mL for 200 minutes	Bell-shaped ROS production (lucigenin chemiluminescence assay)	Ohyama et al. (2007)
$PM_{2.5}$ from Vermont, USA	Murine alveolar type 2 cells	Water (sonication)	10 μg/cm² for 1–8 h	Increased ROS (DCFH)	Shukla et al. (2000)
PM_{10} from Beijing, China	A549	Water (sonication)	10 μg/mL for 24 h	Increased ROS production (DCFH and DHE) by particles as well as soluble and insoluble fractions thereof	Yi et al. (2014)
$PM_{2.5}$ from Denver, Colorado, USA	NR8383 AMs	Water (shaking)	20–200 pg/cell for 2 h	Increased ROS production. Positive association with iron, soil dust sources, and water-soluble carbon	Zhang et al. (2008)
SRM 1648	AMs and type 2 cells	NA	20 μg/cm² (or 200 μg/mL) for 20 h	Increased ROS production in type 2 cells, but not macrophages	Becher et al. (2007)

Supplemental Table S22 (continued)

Particles	Cells	Extraction	Exposure conditions	Effect	Reference
Oil fly ash from a power plant in Sicily, Italy	A549	Water	17.2–68.8 of $VOSO_4$ equiv for 0.5–4 h	Concentration-dependent increase in ROS production (DCFH) Ameliorated by treatment with DFO	Di Pietro et al. (2009)
Coal fly ash from a dumping site of a thermal power plant in Aligarh, India	Mononuclear blood cells	DMSO (0.5%) or water (sonication)	600–2400 ppm for 24 h	Increased generation of ROS (DCFH) by DMSO (0.5%) and ROS production by aqueous extract	Dwivedi et al. (2012)
SRM 1648	Human pulmonary artery endothelial cells	NA	1–100 µg/mL for 5–120 minutes	Concentration- and time-dependent increase in ROS production (Amplex Red)	Li et al. (2006)
SRM 1648	RAW 264.7	NA	62.5 µg/cm² for 4 h	Increased ROS (DCFH)	Schneider et al. (2005)
PM_{10}, $PM_{2.5}$, PM_1, and $PM_{0.4}$ from Milan, Italy, collected during summer or winter	A549 and THP-1	Water (sonication)	10 µg/cm² for 1 h	All size fractions increased ROS production. Samples collected during winter generally slightly more potent than samples collected during summer	Longhin et al. (2013)
PM_{10} from Utah Valley, Utah, USA, dust from 3 different years	AMs	Water (sonication)	≤ 1 mg/mL for 20 minutes or 24 h	Increased ROS production (chemiluminescence) by samples from the year of collection, which was not affected by DFO treatment. Unaltered (or decreased) ROS production by dihydrorhodamine 123 assay	Soukup et al. (2000)
ROFA and CAPs from Boston, Massachusetts, USA	Hamster AMs	Water (sonication)	25–200 µg/mL for 0.5 h	Concentration-dependent increase in ROS production (DCFH), which was inhibited by DFO. Substantial variation in ROS production by CAPs collected on different days	Goldsmith et al. (1998)
EOM of PM from Taiwan, China	MCF-7	Hexane/acetone (ultrasound)	0.04–0.05 m³-air equiv for 24–72 h	No clear difference between PM from urban and rural sites in regard to ROS production (DCFH)	Chen et al. (2013)
EOM of PM_{10} from Kaifaqu district, Dalian, China	HepG2	Sequential extraction in DCM, acetone, and methanol	7.5–30 mg/mL for 1 h	Concentration-dependent increase in ROS production (DCFH)	Jiang et al. (2011)
EOM of road tunnel particles from Shanghai, China	A549	DCM (sonication)	10–400 µg/mL for 1 h	Concentration-dependent increase	Shang et al. (2013)

AMs, alveolar macrophages; CAPs, concentrated ambient particles; DCFH, 2′,7′-dichlorodihydrofluorescein; DCM, dichloromethane; DFO, deferoxamine; DHE, dihydroethidium; DHR, dihydrorhodamine 123; DMSO, dimethyl sulfoxide; EOM, extractable organic matter; equiv, equivalent; h, hour or hours; NA, not applicable; PM, particulate matter; PM_{10}, particulate matter with particles of aerodynamic diameter < 10 µm; $PM_{2.5}$, particulate matter with particles of aerodynamic diameter < 2.5 µm; ROFA, residual oil fly ash; ROS, reactive oxygen species; SRM, standard reference mixture.

Supplemental Table S23 Acellular production of reactive oxygen species

Particles	Extraction	Method	Effect	Reference
Fine particles from Duisburg, Germany	Water (sonication)	ESR with H_2O_2 and DMPO as spin trap	Concentration-dependent increase in ROS production (DMPO-OH signal), which was inhibited by DFO or catalase	Knaapen et al. (2002)
TSP from the city centre of Athens, the suburb of Piraeus, or street dust, Greece	PBS (sonication)	ESR with H_2O_2 and without DMPO	Little difference in potency between TSP from different locations, whereas street dust generated lower levels of ROS. Decreased ROS production by treatment with DFO	Valavanidis et al. (2000)
TSP, PM_{10}, and $PM_{2.5}$ from Athens, Greece	Water (sonication)	ESR with H_2O_2 and without DMPO	Detection of DMPO-OH signals. No difference between size fractions	Valavanidis et al. (2005)
Coal fly ash from a dumping site of a thermal power plant in Aligarh, India	DMSO (0.5%) or water (sonication)	NTB	Increased generation of ROS by DMSO (0.5%) and aqueous extract	Dwivedi et al. (2012)
Coal fly ash from a power plant in Arnhem, Netherlands	Not specified	ESR with DMPO	Detection of DMPO-OH signals. Association between ROS production and release of iron	van Maanen et al. (1999)
$PM_{2.5}$ from San Joaquin Valley, California, USA	Salt solution (shaking)	Benzoate as chemical probe of hydroxyl radicals	Particles from urban area more potent than particles from rural area. Treatment with DFO decreased ROS production	Shen et al. (2011), Shen & Anastasio (2011, 2012)
SRM 1648 or SRM 1649	Water	Deoxyribose assay	Concentration-dependent increase in ROS production. SRM 1649 more potent than SRM 1648. Inhibition of ROS production by DFO	Ball et al. (2000)
PM from Utah Valley, Utah, USA	Water (agitation)	Deoxyribose assay with H_2O_2	Higher ROS production by samples collected during activity at a steel mill. Decreased ROS production by DFO or antioxidant (DMTU or DMSO) treatment	Frampton et al. (1999)
Aqueous extract from Utah Valley, Utah, USA, before, during, and after a strike at the steel mill	Water (agitation)	Deoxyribose assay	Increased ROS production in samples before and after the strike compared with samples collected during the strike. Decreased ROS production by treatment with DFO or DMTU	Ghio & Devlin (2001)
Water-soluble or insoluble fraction of CAPs from Boston, Massachusetts, USA	Water (sonication)	DCFH with H_2O_2	Only ROS production in the presence of H_2O_2. Water-soluble fraction more potent than insoluble fraction. Diminished ROS production by treatment with DFO	Imrich et al. (2007)
PM_{10} from an urban street in Stockholm, Sweden	Water (sonication)	DTT	Concentration-dependent increase, which was slightly inhibited by DFO	Lindbom et al. (2007)
$PM_{2.5}$ from urban air particulates at 20 different sites (19 European cities)	Water	ESR and H_2O_2 with DMPO as spin trap	Different ROS production potential between sites and over time. Heterogeneous association between ROS production and PM constituents across locations	Künzli et al. (2006), Nawrot et al. (2009)
$PM_{2.5}$ from 5 cities in the USA	PBS (vortexing)	ESR	Similar ESR spectra of samples collected in different cities, whereas no ESR signal observed in blank filters	Dellinger et al. (2001)

Supplemental Table S23 (continued)

Particles	Extraction	Method	Effect	Reference
PM from a town with many wood stoves and a rural area, Denmark	Mechanical collection from plates	ESR (with ascorbate and DMPO) and DCFH	Rural particles more potent than city particles by ESR. Same ROS production by particles for the DCFH assay	Danielsen et al.(2011)
Fine and coarse particles from Duisburg (industrial area) and Borken (rural area), Germany	Water (sonication)	ESR with H_2O_2 and DMPO as spin trap	Fine and coarse particles from Borken generated the same level of ROS. Coarse particles from Duisburg generated more ROS than fine particles	Schins et al. (2004)
Fine and coarse particles from various cities in Germany	Water (sonication)	ESR with H_2O_2 and DMPO as spin trap	Coarse particles generated higher level of ROS than fine particles. Samples from industrial area (Dortmund and Duisburg) generated higher level of ROS than samples from rural site (Borken)	Shi et al. (2006)
$PM_{2.5}$ from a smelter site and non-industrialized site in Germany	Water (sonication)	ESR	Higher levels of ROS production in samples from industrial area	Schaumann et al. (2004)
PM_{10} from an urban or suburban site in Mexico City, Mexico	Mechanically recovered	ESR with H_2O_2 and DMPO as spin trap	Particles from urban site more potent than particles from suburban site. Temporal variation related to wind direction at sampling site	Quintana et al. (2011)
PM_{10} from a busy street in Maastricht, Netherlands	Not specified	ESR with DMPO as spin trap	Presence of oxygen radicals, but no carbon-centred radicals	de Kok et al. (2004)
PM_{10} from Edinburgh, Scotland	Water (sonication)	2.3-dihydroxybenzoic acid production	Increased ROS production	Donaldson et al. (1997)
Aqueous extract or insoluble fraction of TSP from North Provo, Utah, USA	Water (agitation)	Deoxyribose assay with H_2O_2	Increased ROS production. Higher response by soluble extract compared with insoluble fraction	Ghio et al. (1999)
PM_{10} from Helsinki, Finland, collected during spring or winter	Methanol (sonication)	ESR with H_2O_2	Increased production, without clear seasonal variation	Salonen et al. (2004)
$PM_{2.5}$ and PM_{10} from different sites in the Netherlands	Water	ESR with H_2O_2 and DMPO as spin trap	PM_{10} from major streets more potent than urban background. PM_{10} more potent than $PM_{2.5}$	Boogaard et al. (2012)
Fine and coarse particles from Düsseldorf, Germany	Water (sonication)	ESR with H_2O_2 and DMPO as spin trap	Coarse PM generated more ROS (DMPO-OH signal) than fine PM when compared at equal mass. Samples collected during summer had stronger ROS generating potency than autumn/winter samples	Shi et al. (2003)
$PM_{2.5}$ and PM_{10} from Maastricht, Netherlands	Not reported	ESR with DMPO as spin trap	No difference in ROS generating ability between $PM_{2.5}$ and PM_{10} samples. Season-dependent variation in ROS generating ability of outdoor PM_{10} samples	Briedé et al. (2005)
$PM_{2.5}$,PM_{10}, or TSP from school playgrounds in Maastricht, Netherlands	No extraction	ESR with DMPO as spin trap	Differences in ROS generation in samples collected at different locations. No clear difference between different size modes	Hogervorst et al. (2006)

Supplemental Table S23 (continued)

Particles	Extraction	Method	Effect	Reference
PM in different size fractions from urban and rural sites, United Kingdom	Water (sonication)	EST with H_2O_2 and DMPO	ROS production highest for sites near traffic. Little effect related to size fractions	Wessels et al. (2010)
$PM_{2.5}$ from San Joaquin Valley, California, USA	Not specified	DTT	Temporal variation in ROS production, although no clear effect of summer and winter	Charrier & Anastasio (2012)
EOM of TSP from Fresno, California, USA	DCM (sonication)	DTT (measured as H_2O_2 production)	Increased ROS production, which correlated with content of 3 active quinones	Chung et al. (2006)
$PM_{2.5}$ from Los Angeles, California, USA, during wildfires	Water	DTT	Increased ROS production by samples collected during wildfire compared with samples collected after wildfire	Verma et al. (2009)
$PM_{2.5}$ from Atlanta, Georgia, USA	Water or methanol	DTT	Day-to-day variation in potency of particles. Methanol extract more potent than water extract	Verma et al. (2012)
Urban and rural sites in Norfolk, Virginia, USA	Water (sonication)	DTT	Ultrafine particles more potent on mass basis than $PM_{2.5}$	Jeng (2010)
Coarse, fine, and ultrafine particles from Los Angeles basin, California, USA	VACES	DTT	Ultrafine particles had higher redox activity than fine and coarse particles on weight basis	Cho et al. (2005)
Coarse or fine particles from Mexico City, Mexico	Water	DTT	Fine particles more potent than coarse particles. Temporal and spatial differences in potency	De Vizcaya-Ruiz et al. (2006)
Coarse, fine, and ultrafine particles from Los Angeles basin, California, USA	VACES	DTT	Ultrafine particles generated higher DDT oxidation than coarse and fine particles on mass basis. Substantial spatial and temporal variation in ROS production ability of ultrafine particles	Li et al. (2003)
PM from Los Angeles and San Francisco, California, USA	VACES	DTT	Higher ROS production on mass basis for ultrafine particles compared with fine and coarse particles. Strong correlation between organic carbon content and ROS production	Ntziachristos et al. (2007)
Coarse, fine, and ultrafine samples from the Netherlands	VACES	DTT	Increased ROS production, with generally the same potency for all size fractions	Steenhof et al. (2011)
$PM_{2.5}$ from Toronto, Canada, and SRM 1648	Water	DTT	Similar level of ROS production of $PM_{2.5}$ and SRM 1648. Water-soluble fraction of SRM 1648 more potent than water-insoluble fraction	Akhtar et al. (2010)

CAPs, concentrated ambient particles; DCFH, 2′,7′-dichlorodihydrofluorescein; DCM, dichloromethane; DFO, deferoxamine; DMPO, 5,5-dimethyl-1-pyrroline-*N*-oxide; DMSO, dimethyl sulfoxide; DMTU, dimethylthiourea; DTT, dithiothreitol; EOM, extractable organic matter; ESR, electron spin resonance; H_2O_2, hydrogen peroxide; PBS, phosphate-buffered saline; PM, particulate matter; PM_{10}, particulate matter with particles of aerodynamic diameter < 10 μm; $PM_{2.5}$, particulate matter with particles of aerodynamic diameter < 2.5 μm; ROS, reactive oxygen species; SRM, standard reference mixture; TSP, total suspended particles; VACES, versatile aerosol concentration enrichment system.

Supplemental Table S24 Genotoxic effects in germ cells of animals exposed to polluted outdoor air

Location	Animals	Experimental design/ exposure	End-point	Results	Call	Reference
Hamilton, Canada	Herring gull	Feral gulls collected from a steel mill environment and rural reference locations	Heritable minisatellite DNA mutation by multilocus DNA fingerprinting	Significant > 2-fold increase in mutation rate observed in offspring from the industrial site compared with rural locations	+	Yauk & Quinn (1996)
Urban and industrial sites, Canada and USA	Herring gull	Feral gulls collected from 4 steel mill environments, 2 urban sites, and 3 rural reference locations	Heritable minisatellite DNA mutation by multilocus DNA fingerprinting	Significant 2-fold increase in mutation rate observed in offspring from the industrial sites compared with rural locations. No difference between urban sites and rural sites. Minisatellite mutation rates decreased with increasing distance from industrial coking oven and urbanization site	+	Yauk et al. (2000)
Hamilton, Canada	Swiss Webster mice, outbred	In situ, 10 wk exposure to outdoor air near steel mills and a rural reference site	Heritable mutation at ESTR loci in offspring conceived 6 wk after exposure	Significant 1.5–2-fold increase in mutation frequency at several loci observed in offspring from the steel mills site compared with rural locations	+	Somers et al. (2002)
Hamilton, Canada	Swiss Webster mice, outbred	In situ, 10 wk exposure to outdoor air near steel mills and a rural reference site	Heritable mutation at ESTR loci in offspring conceived 9 wk after exposure	Offspring of mice from the urban/industrial site showed 1.9–2.1-fold increased mutation frequency in ESTR of paternal origin, compared with offspring from rural locations. HEPA filtration of outdoor air significantly reduced heritable mutation rates	+	Somers et al. (2004)
Hamilton, Canada	C57BL/CBA F1 mice, inbred	In situ, mice exposed to outdoor air near steel mills or HEPA-filtered air for 3, 10, or 16 wk, followed by 6 wk in the laboratory	ESTR loci mutation in sperm; DNA adducts in testes; DNA damage in sperm	Significant 1.6-fold increase in germline mutation frequency at Ms6-hm observed in mice exposed to outdoor air at the steel mills site compared with HEPA-filtered air after 16 wk, but not at 3 wk or 10 wk. DNA strand breaks in mature sperm were significantly elevated in the outdoor air-exposed group after 3 wk. No detectable DNA adducts observed in testes samples	+	Yauk et al. (2008)
Rome, Italy	Wild mice *Mus domesticus*	Feral mice collected from 3 sites of low, medium, and high air pollution from traffic	Abnormality on the sperm cells of cauda epididymis	Significant increase in frequency of abnormal sperm cells from sites with medium ($P < 0.05$) and heavy ($P < 0.01$) pollution compared with low-air-pollution control site. Sperm abnormality includes banana-like form, narrow form without hook, with 2 tails and triangular head, amorphous, and folded form	+	Ieradi et al. (1996)

Supplemental Table S24 (continued)

Location	Animals	Experimental design/ exposure	End-point	Results	Call	Reference
Shanghai, China	Male mice (strain not specified)	Mice treated with extracts of TSP collected from 13 sites in Shanghai	Sperm morphology, shape of normal and abnormal heads	Increased germ-cell deformations observed for most sites in winter, especially for the sites of Yang Pu, Huang Pu, and Western Suburb Park	+	Mao et al. (1993)
Kunming, China	Oregon R male *Drosophila*	*Drosophila* fed with particulate extracts for 3 days at concentrations of 0.1% and 0.2% of stock solution of TSP extract from Kunming	Germ-cell mutation in *Drosophila* by sex-linked recessive lethal test (SLRL)	Treatment of ¼ and ½ LC_{50} in male *Drosophila* caused mutation with frequency of 0.76% and 0.92%, respectively. No mutation observed in the control	+	Yang & Lu (1989)
Magnitogorsk, Russian Federation	*Drosophila melanogaster*	Exposure to outdoor air and snow samples from different Magnitogorsk areas, 4 yr monitoring	Dominant lethal induction in gametes	Positive induction of DLM in the gametes of *Drosophila*; positive correlation between all genotoxic chemicals found in the outdoor air and the rate of DLM	+	Legostaeva et al. (2010)

DLM, dominant lethal mutation; ESTR, expanded simple tandem repeat; HEPA, high-efficiency particulate air; LC_{50}, median lethal concentration; TSP, total suspended particulates; wk, week or weeks; yr, year or years.

Supplemental Table S25 Studies that used cultured animal cells to assess the ability of outdoor air to induce malignant cell transformation

Geographical location	Test article	Assay/exposure system	End-point(s) examined	Results	Reference
Rhine–Ruhr region, Germany	"City smog" collected at heavily industrialized location (17), collected on GFFs. MeOH extraction, followed by CX and Pro fractionation	Syrian hamster kidney cells, 18 h exposure to extract in DMSO and subsequently infected with SV40	Cell transformation	Significant dose-related (equiv m^3/assay) increase in transformation frequency induced by total extract (up to 20-fold vs control). MeOH and CX fractions also elicited significant increase in transformation frequency. Inoculation of cells transformed in vitro in Syrian golden hamsters elicited malignant tumours	Seemayer. et al. (1981, 1984)
Duisburg, Germany	Airborne PM from industrialized Rhine–Ruhr region, Draeger Box Micron filter. CX extraction	Syrian hamster kidney cells, 18 h exposure to extract in DMSO and subsequently infected with SV40	Cell transformation	Significant dose-related (m^3 equiv/mL) increase in transformation frequency. As little as 0.25–0.5 m^3 equiv elicited a significant enhancement in transformation frequency	Seemayer et al. (1987a), Seemayer et al. (1988)
Rhine–Ruhr region, Germany	20 samples of "city smog" collected between 1975 and 1986 at highly industrialized locations, collected on GFFs. Organic extraction	Syrian hamster kidney cells, 18 h exposure to extract in DMSO and subsequently infected with SV40	Cell transformation	Düsseldorf provided as an example. Significant dose-related (equiv m^3/mL) increase in transformation frequency. As little as 0.5 m^3 equiv elicited a significant enhancement in transformation frequency	Seemayer et al. (1987b)
Rhine–Ruhr region, Germany	41 samples of "city smog" collected between 1975 and 1990 at highly industrialized locations, collected on GFFs. Organic extraction	Syrian hamster kidney cells, 18 h exposure to extract in DMSO and subsequently infected with SV40	Cell transformation	Site 54 (Düsseldorf) shown as an example. Significant dose-related (equiv m^3/mL) increase in transformation frequency. As little as 0.5 m^3 equiv elicited a significant enhancement in transformation frequency	Seemayer et al. (1990a)
Rhine–Ruhr region, Germany.	Airborne PM from Duisburg and Düsseldorf, collected on GFFs with high-volume sampler. DCM extraction	Syrian hamster kidney cells, 18 h exposure to extract in DMSO and subsequently infected with SV40	Cell transformation	Significant dose-related (equiv m^3/assay) increase in transformation frequency. Less than 1 m^3 equiv required to elicit a significant enhancement in transformation frequency. Higher responses in March compared with October	Seemayer et al. (1990a)
Rhine–Ruhr region, Germany.	Airborne PM from Duisburg and Düsseldorf, collected on GFFs with high-volume sampler. DCM extraction	Syrian hamster kidney cells, 18 h exposure to extract in DMSO and subsequently infected with SV40	Cell transformation	Significant dose-related (equiv m^3/assay) increase in transformation frequency. As little as 0.5 m^3 equiv elicited a significant enhancement in transformation frequency. Inoculation of cells transformed in vitro in Syrian golden hamsters produced malignant tumours (mostly sarcomas)	Seemayer & Hornberg (1998)

Supplemental Table S25 (continued)

Geographical location	Test article	Assay/exposure system	End-point(s) examined	Results	Reference
Athens, Greece (1983)	Monthly PM samples collected on cellulose filters with high-volume sampler. Hx sonication extraction	BALB/c 3T3 cells, 48 h treatment with extract in DMSO	Cell transformation (type III foci)	Significant dose-related (μg of EOM/mL) increase in transformation frequency	Athanasiou et al. (1987)
Shanghai, China	TSP from 4 locations in industrial Baoshan industrial district. DEE Soxhlet extraction	CHO fibroblasts, treated with extracts in DMSO	Cell transformation	3 of the 4 samples examined induced a significant increase in transformation frequency	Lu et al. (1997)
Tokyo, Japan (1980–1983)	Airborne PM from single urban site, collected on quartz filters with high-volume sampler. DCM sonication extraction	Bhas42 cells (BALB/c 3T3 transfected with v-Ha-*ras*), treated for 3, 7, and 10 days with extracts in DMSO	Cell transformation	Significant dose-related (μg of PM/mL) increase in transformation frequency. Higher potency (per mg of PM) in autumn compared with spring	Ezoe et al. (2004)

CHO, Chinese hamster ovary; CX, cyclohexane; DCM, dichloromethane; DEE, diethyl ether; DMSO, dimethyl sulfoxide; EOM, extractable organic matter; h, hour or hours; equiv, equivalent; GFFs, glass-fibre filters; Hx, hexane; MeOH, methanol; PM, particulate matter; SV40, simian virus 40.

Supplemental Table S26 Influence of genotype and lung cancer risk

Exposure group	Country	Genotype/phenotype method	Result	*P* value	Reference
GenAir is a case–control study nested within the EPIC cohort	EPIC, Europe	*NAT1*, *NAT2*, *GSTM1*, *GSTM3*, *GSTT1*, *GSTPi*, *CYP1A1*, *CYP1B1*, *MnSOD*, *MPO*, *NQO1*	A polymorphism for *NQO1* (involved in oxidative damage scavenging) was strongly associated with lung cancer	Odds ratio of 8.06 (95% CI, 1.74–37.41) for the homozygous variant	Vineis et al. (2006)
GenAir	EPIC, Europe	Several genes	*XRRC* and *BRCA* variants in gene–environment interactions in lung cancer. More genes reported associated with bladder cancer and leukaemia		Manuguerra et al. (2007)
GenAir	EPIC, Europe	*GSTM1*, *XRCC1*	Profile regression analysis of DNA adducts showed increased risk from *GSTM1* null		Papathomas et al. (2011)
Indoor air pollution Coal exposure	Asia: 5 studies from China and 1 from Thailand	*GSTM1*, *GSTT1*, *GSTP1*	*GSTM1* null genotype associated with cancer risk in 4 studies	0.001	Hosgood et al. (2007)

CI, confidence interval; EPIC, European Prospective Investigation into Cancer and Nutrition.

Supplemental Table S27 Influence of genotype and biomarkers in humans

Exposure group	Country	Genotype/ phenotype method	Result	*P* value	Reference
Bus drivers and garage workers	Czech Republic	Several genes	The carriers of at least one variant hOGG1 (Cys) allele tended to higher oxidative damage to lymphocyte DNA than those with the wild genotype, whereas XPD23 (Gln/Gln) homozygotes were more susceptible to the induction of DNA strand breaks. In contrast, *GSTM1* null variant seemed to protect DNA integrity		Bagryantseva et al. (2010)
Police officers	Czech Republic	Several genes	The carriers of at least one variant allele, CYP1A1*2C (Ile/Val), MTHFR 2656, or MS 2656, and the EPHX1-medium phenotype appeared to be more susceptible specifically to the induction of oxidative damage to DNA		Novotna et al. (2007)
Outdoor air pollution, traffic police	Czech Republic	*GSTM1*	*GSTM1* null genotype associated with increased sperm DNA damage		Rubes et al. (2010)
Traffic police	India	*CYP1A1*, *GSTM1*, *GSTT1*	*CYP1A1* m1 and *GSTM1* null showed increased 8-OHdG		Prasad et al. (2013)
Outdoor air pollution Bus drivers and mail carriers	Denmark	*GSTM1* *NAT2*	DNA adducts: no significant effects CAs: increased in bus drivers with *GSTM1* null and *NAT2* slow acetylator CAs: increased in mail carriers with *NAT2* slow acetylator	0.0005	Nielsen et al. (1996b), Knudsen et al. (1999)
Bus drivers	Denmark	Urinary *CYP1A2* activity	Urinary 8-OHdG: correlation with *CYP1A2* activity	0.05	Loft et al. (1999)
Bus drivers and mail carriers	Denmark	*NAT2*	Mutagenic activity in urine increased in bus drivers with *NAT2* fast acetylator (see Section 4.2.1a)		Hansen et al. (2004)
Workers and residents exposed to traffic	Italy	*XPD*, *XRCC1*, *XRCC3*	DNA adducts: no significant effects		Palli et al. (2001)
Children exposed to urban air pollution	Bangkok, Thailand	*CYP1A1*, *GSTM1*, *GSTT1*	DNA adducts and 1-OHP: no significant effects		Ruchirawat et al. (2007)

CAs, chromosomal aberrations; NAT2, *N*-acetyltransferase 2; 1-OHP, 1-hydroxypyrene; 8-OHdG, 8-hydroxydeoxyguanosine.

References

Abbas I, Saint-Georges F, Billet S, Verdin A, Mulliez P, Shirali P et al. (2009). Air pollution particulate matter ($PM_{2.5}$)-induced gene expression of volatile organic compound and/or polycyclic aromatic hydrocarbon-metabolizing enzymes in an in vitro coculture lung model. *Toxicol In Vitro*, 23(1):37–46. doi:10.1016/j.tiv.2008.09.020 PMID:18952161

Adamson IY, Prieditis H, Hedgecock C, Vincent R (2000). Zinc is the toxic factor in the lung response to an atmospheric particulate sample. *Toxicol Appl Pharmacol*, 166(2):111–9. doi:10.1006/taap.2000.8955 PMID:10896852

Adamson IY, Prieditis H, Vincent R (1999a). Pulmonary toxicity of an atmospheric particulate sample is due to the soluble fraction. *Toxicol Appl Pharmacol*, 157(1):43–50. doi:10.1006/taap.1999.8658 PMID:10329506

Adamson IY, Vincent R, Bjarnason SG (1999b). Cell injury and interstitial inflammation in rat lung after inhalation of ozone and urban particulates. *Am J Respir Cell Mol Biol*, 20(5):1067–72. doi:10.1165/ajrcmb.20.5.3468 PMID:10226078

Adonis M, Gil L (1993). Mutagenicity of organic extracts from Santiago (Chile) airborne particulate matter. *Mutat Res*, 292(1):51–61. doi:10.1016/0165-1161(93)90007-M PMID:7688097

Adonis M, Gil L (2000). Polycyclic aromatic hydrocarbon levels and mutagenicity of inhalable particulate matter in Santiago, Chile. *Inhal Toxicol*, 12(12):1173–83. doi:10.1080/08958370050198520 PMID:11114787

Adonis M, Quinones L, Gil L, Gibson G (1997). Hepatic enzyme induction and mutagenicity of airborne particulate matter from Santiago, Chile in the nourished and malnourished rat. *Xenobiotica*, 27(5):527–36. doi:10.1080/004982597240488 PMID:9179992

Agurell E, Stensman C (1992). *Salmonella* mutagenicity of three complex mixtures assayed with the microsuspension technique. A WHO/IPCS/CSCM study. *Mutat Res*, 276(1–2):87–91. doi:10.1016/0165-1110(92)90057-G PMID:1370111

Akhtar US, McWhinney RD, Rastogi N, Abbatt JP, Evans GJ, Scott JA (2010). Cytotoxic and proinflammatory effects of ambient and source-related particulate matter (PM) in relation to the production of reactive oxygen species (ROS) and cytokine adsorption by particles. *Inhal Toxicol*, 22:Suppl 2:37–47. doi:10.3109/08958378.2010.518377 PMID:21142797

al-Khodairy F, Al-Dakan A, Akel M, Hannan MA (1998). A comparative analysis of mutagenic activities of air samples collected from Riyadh before, during and after the Gulf War. *Int J Environ Health Res*, 8(1):15–22. doi:10.1080/09603129873615

al-Khodairy F, Hannan MA (1997). Exposure of organic extracts of air particulates to sunlight leads to metabolic activation independence for mutagenicity. *Mutat Res*, 391(1–2):71–7. doi:10.1016/S0165-1218(97)00035-9 PMID:9219550

al-Sabti K (1989). *Allium* test for air and water borne pollution control. *Cytobios*, 58(233):71–8. PMID:2805813

Alfaro-Moreno E, Martínez L, García-Cuellar C, Bonner JC, Murray JC, Rosas I et al. (2002). Biologic effects induced in vitro by PM_{10} from three different zones of Mexico City. *Environ Health Perspect*, 110(7):715–20. doi:10.1289/ehp.02110715 PMID:12117649

Alfheim I, Hongslo J, Moller M, Ramdahl T, Sortland B, Wikström L et al. (1984). Air pollution from aluminum smelting plants. II. The contribution from an aluminum smelting plant using the Söderberg process to polycyclic aromatic hydrocarbons and mutagens in ambient air. *Toxicol Environ Chem*, 8(2–3):195–212. doi:10.1080/02772248409357052

Alfheim I, Jebens A, Johansen S (1985). Sampling ambient air for mutagenicity testing by high-volume filtration on glass-fiber filters and on XAD-2. *Environ Int*, 11(2–4):111–8. doi:10.1016/0160-4120(85)90003-0

Alfheim I, Lindskog A (1984). A comparison between different high volume sampling systems for collecting ambient airborne particles for mutagenicity testing and for analysis of organic compounds. *Sci Total Environ*, 34(3):203–22. doi:10.1016/0048-9697(84)90064-0 PMID:6719098

Alfheim I, Löfroth G, Møller M (1983). Bioassay of extracts of ambient particulate matter. *Environ Health Perspect*, 47:227–38. doi:10.1289/ehp.8347227 PMID:6186477

Alink GM, Smit HA, van Houdt JJ, Kolkman JR, Boleij JS (1983). Mutagenic activity of airborne particulates at non-industrial locations. *Mutat Res*, 116(1):21–34. doi:10.1016/0165-1218(83)90003-4 PMID:6828047

Alzuet PR, Gaspes E, Ronco AE (1996). Mutagenicity of environmental samples from an industrialized area of the Rio de la Plata Estuary using the *Salmonella*/microsomal assay. *Environ Toxicol Water Qual*, 11(3):231–6. doi:10.1002/(SICI)1098-2256(1996)11:3<231::AID-TOX8>3.0.CO;2-A

Amador-Muñoz O, Delgado-Rodriguez A, Villalobos-Pietrini R Munive-Colin Z, Ortíz-Marttello R, Díaz-Gonzáles G et al. (2001). Airborne particles, polycyclic aromatic hydrocarbons and mutagenicity in southwest Mexico City [in Spanish]. *Rev Int Contam Ambient*, 17(4):193–204.

Andrade Jr SJ, Santos Junior JCS, Oliveira JL, Cerquiera EMM, Meireles JRC (2008). Micronuclei in tetrads of *Tradescantia pallida* (Rose) Hunt. cv. *purpurea* Boom: genetic changes caused by urban air pollution. *Acta Sci Biol Sci*, 30:295–301.

André E, Stoeger T, Takenaka S, Bahnweg M, Ritter B, Karg E et al. (2006). Inhalation of ultrafine carbon particles triggers biphasic pro-inflammatory response in the mouse lung. *Eur Respir J*, 28(2):275–85. doi:10.1183/09031936.06.00071205 PMID:16641123

André V, Billet S, Pottier D, Le Goff J, Pottier I, Garçon G et al. (2011). Mutagenicity and genotoxicity of $PM_{2.5}$ issued from an urbano-industrialized area of Dunkerque (France). *J Appl Toxicol*, 31(2):131–8. PMID:20687134

Andrysík Z, Vondráček J, Marvanová S, Ciganek M, Neča J, Pěnčíková K et al. (2011). Activation of the aryl hydrocarbon receptor is the major toxic mode of action of an organic extract of a reference urban dust particulate matter mixture: the role of polycyclic aromatic hydrocarbons. *Mutat Res*, 714(1-2):53–62. doi:10.1016/j.mrfmmm.2011.06.011 PMID:21762708

Arey J, Harger WP, Helmig D, Atkinson R (1992). Bioassay-directed fractionation of mutagenic PAH atmospheric photooxidation products and ambient particulate extracts. *Mutat Res*, 281(1):67–76. doi:10.1016/0165-7992(92)90038-J PMID:1371594

Arey J, Zielinska B, Harger WP, Atkinson R, Winer AM (1988). The contribution of nitrofluoranthenes and nitropyrenes to the mutagenic activity of ambient particulate organic matter collected in southern California. *Mutat Res*, 207(2):45–51. doi:10.1016/0165-7992(88)90040-1 PMID:3340093

Athanasiou K, Arzimanoglou I, Piccoli C, Yamasaki H, Arzimanoglou II (1987). Mutagenicity, sister chromatid exchange inducibility and in vitro cell transforming ability of particulates from Athens air. *Cell Biol Toxicol*, 3(3):251–61. doi:10.1007/BF00117863 PMID:3333731

Athanasiou K, Viras LG, Siskos PA (1986). Mutagenicity and polycyclic aromatic hydrocarbons analysis of ambient airborne particles collected in Athens, Greece. *Sci Total Environ*, 52(3):201–9. doi:10.1016/0048-9697(86)90120-8 PMID:3526551

Auger F, Gendron MC, Chamot C, Marano F, Dazy AC (2006). Responses of well-differentiated nasal epithelial cells exposed to particles: role of the epithelium in airway inflammation. *Toxicol Appl Pharmacol*, 215(3):285–94. doi:10.1016/j.taap.2006.03.002 PMID:16647095

Autrup H, Vestergaard AB (1996). Transplacental transfer of environmental genotoxins – polycyclic aromatic hydrocarbon-albumin in nonsmoking women. *Environ Health Perspect*, 104:Suppl 3: 625–7. PMID:8781394

Bagate K, Meiring JJ, Gerlofs-Nijland ME, Vincent R, Cassee FR, Borm PJ (2004). Vascular effects of ambient particulate matter instillation in spontaneous hypertensive rats. *Toxicol Appl Pharmacol*, 197(1):29–39. doi:10.1016/j.taap.2004.02.005 PMID:15126072

Bagley ST, Stoltz SL, Becker DM, Keen RE (1992). Characterization of organic extracts from standard reference materials 1649, 'urban dust/organics,' and 1650, 'diesel particulate matter', using a microsuspension assay. A WHO/IPCS/CSCM study. *Mutat Res*, 276(1–2):81–6. doi:10.1016/0165-1110(92)90056-F PMID:1370110

Bagryantseva Y, Novotna B, Rossner P Jr, Chvatalova I, Milcova A, Svecova V et al. (2010). Oxidative damage to biological macromolecules in Prague bus drivers and garagemen: impact of air pollution and genetic polymorphisms. *Toxicol Lett*, 199(1):60–8. doi:10.1016/j.toxlet.2010.08.007 PMID:20723587

Ball JC, Straccia AM, Young WC, Aust AE (2000). The formation of reactive oxygen species catalyzed by neutral, aqueous extracts of NIST ambient particulate matter and diesel engine particles. *J Air Waste Manag Assoc*, 50(11):1897–903. doi:10.1080/10473289.2000.10464231 PMID:11111334

Barale R, Giorgelli F, Scarpato R, Scapoli C, Loprieno N, Barrai I (1991b). Correlation between mutagenicity of airborne particles and air pollution parameters in eleven Italian towns. *Int J Environ Health Res*, 1(1):37–53. doi:10.1080/09603129109356703

Barale R, Giromini L, Del Ry S, Barnini B, Bulleri M, Barrai I et al. (1994). Chemical and mutagenic patterns of airborne particulate matter collected in 17 Italian towns. *Environ Health Perspect*, 102:Suppl 4:67–73. doi:10.1289/ehp.94102s467 PMID:7821298

Barale R, Giromini L, Ghelardini G, Scapoli C, Loprieno N, Pala M et al. (1991a). Correlations between 15 polycyclic aromatic hydrocarbons (PAH) and the mutagenicity of the total PAH fraction in ambient air particles in La Spezia (Italy). *Mutat Res*, 249(1):227–41. doi:10.1016/0027-5107(91)90150-M PMID:2067536

Barale R, Zucconi D, Giorgelli F, Carducci AL, Tonelli M, Loprieno N (1989). Mutagenicity of airborne particles from a nonindustrial town in Italy. *Environ Mol Mutagen*, 13(3):227–33. doi:10.1002/em.2850130306 PMID:2468490

Bastonini E, Verdone L, Morrone S, Santoni A, Settimo G, Marsili G et al. (2011). Transcriptional modulation of a human monocytic cell line exposed to PM_{10} from an urban area. *Environ Res*, 111(6):765–74. doi:10.1016/j.envres.2011.06.005 PMID:21741637

Batalha JR, Guimarães ET, Lobo DJ, Lichtenfels AJ, Deur T, Carvalho HA et al. (1999). Exploring the clastogenic effects of air pollutants in São Paulo (Brazil) using the *Tradescantia* micronuclei assay. *Mutat Res*, 426(2):229–32. doi:10.1016/S0027-5107(99)00073-1 PMID:10350603

Baulig A, Sourdeval M, Meyer M, Marano F, Baeza-Squiban A (2003). Biological effects of atmospheric particles on human bronchial epithelial cells. Comparison with diesel exhaust particles. *Toxicol In Vitro*, 17(5–6):567–73. doi:10.1016/S0887-2333(03)00115-2 PMID:14599446

Bayona JM, Casellas M, Fernández P, Solanas AM, Albaigés J (1994). Sources and seasonal variability of mutagenic agents in the Barcelona City aerosol. *Chemosphere*, 29(3):441–50. doi:10.1016/0045-6535(94)90432-4 PMID:7522908

Becher R, Bucht A, Øvrevik J, Hongslo JK, Dahlman HJ, Samuelsen JT et al. (2007). Involvement of NADPH oxidase and iNOS in rodent pulmonary cytokine responses to urban air and mineral particles. *Inhal*

Toxicol, 19(8):645–55. doi:10.1080/08958370701353528 PMID:17510837

Becker S, Dailey LA, Soukup JM, Grambow SC, Devlin RB, Huang YC (2005). Seasonal variations in air pollution particle-induced inflammatory mediator release and oxidative stress. *Environ Health Perspect*, 113(8):1032–8. doi:10.1289/ehp.7996 PMID:16079075

Becker S, Soukup JM, Gilmour MI, Devlin RB (1996). Stimulation of human and rat alveolar macrophages by urban air particulates: effects on oxidant radical generation and cytokine production. *Toxicol Appl Pharmacol*, 141(2):637–48. doi:10.1006/taap.1996.0330 PMID:8975789

Billet S, Garçon G, Dagher Z, Verdin A, Ledoux F, Cazier F et al. (2007). Ambient particulate matter ($PM_{2.5}$): physicochemical characterization and metabolic activation of the organic fraction in human lung epithelial cells (A549). *Environ Res*, 105(2):212–23. doi:10.1016/j.envres.2007.03.001 PMID:17462623

Binková B, Cerná M, Pastorková A, Jelínek R, Benes I, Novák J et al. (2003). Biological activities of organic compounds adsorbed onto ambient air particles: comparison between the cities of Teplice and Prague during the summer and winter seasons 2000–2001. *Mutat Res*, 525(1–2):43–59. doi:10.1016/S0027-5107(02)00312-3 PMID:12650904

Binková B, Lenícek J, Benes I, Vidová P, Gajdos O, Fried M et al. (1998). Genotoxicity of coke-oven and urban air particulate matter in in vitro acellular assays coupled with 32P-postlabeling and HPLC analysis of DNA adducts. *Mutat Res*, 414(1-3):77–94. doi:10.1016/S1383-5718(98)00040-0 PMID:9630530

Binková B, Lewtas J, Mísková I, Rössner P, Cerná M, Mrácková G et al. (1996). Biomarker studies in northern Bohemia. *Environ Health Perspect*, 104:Suppl 3: 591–7. doi:10.1289/ehp.96104s3591 PMID:8781388

Binková B, Veselý D, Veselá D, Jelínek R, Srám RJ (1999). Genotoxicity and embryotoxicity of urban air particulate matter collected during winter and summer period in two different districts of the Czech Republic. *Mutat Res*, 440(1):45–58. doi:10.1016/S1383-5718(99)00011-X PMID:10095128

Bonetta S, Gianotti V, Bonetta S, Gosetti F, Oddone M, Gennaro MC et al. (2009). DNA damage in A549 cells exposed to different extracts of $PM_{2.5}$ from industrial, urban and highway sites. *Chemosphere*, 77(7):1030–4. doi:10.1016/j.chemosphere.2009.07.076 PMID:19729187

Boogaard H, Janssen NA, Fischer PH, Kos GP, Weijers EP, Cassee FR et al. (2012). Contrasts in oxidative potential and other particulate matter characteristics collected near major streets and background locations. *Environ Health Perspect*, 120(2):185–91. doi:10.1289/ehp.1103667 PMID:22015682

Bos I, De Boever P, Emmerechts J, Buekers J, Vanoirbeek J, Meeusen R et al. (2012). Changed gene expression in brains of mice exposed to traffic in a highway tunnel. *Inhal Toxicol*, 24(10):676–86. doi:10.3109/08958378.2012.714004 PMID:22906174

Briedé JJ, De Kok TM, Hogervorst JG, Moonen EJ, Op Den Camp CL, Kleinjanst JC (2005). Development and application of an electron spin resonance spectrometry method for the determination of oxygen free radical formation by particulate matter. *Environ Sci Technol*, 39(21):8420–6. doi:10.1021/es0485311 PMID:16294882

Brits E, Schoeters G, Verschaeve L (2004). Genotoxicity of PM_{10} and extracted organics collected in an industrial, urban and rural area in Flanders, Belgium. *Environ Res*, 96(2):109–18. doi:10.1016/j.envres.2004.03.006 PMID:15325871

Bronzetti G, Cini M, Paoli M, Ciacchini G, Giaconi V, Morichetti E (1997). Mutagenicity and chemical analysis of airborne particulate matter collected in Pisa. *J Environ Pathol Toxicol Oncol*, 16(2–3):147–56. PMID:9275995

Brown DM, Donaldson K, Stone V (2004). Effects of PM_{10} in human peripheral blood monocytes and J774 macrophages. *Respir Res*, 5(1):29 doi:10.1186/1465-9921-5-29 PMID:15613243

Brown DM, Hutchison L, Donaldson K, Stone V (2007). The effects of PM_{10} particles and oxidative stress on macrophages and lung epithelial cells: modulating effects of calcium-signaling antagonists. *Am J Physiol Lung Cell Mol Physiol*, 292(6):L1444–51. doi:10.1152/ajplung.00162.2006 PMID:17369293

Brown LE, Trought KR, Bailey CI, Clemons JH (2005). 2,3,7,8-TCDD equivalence and mutagenic activity associated with PM_{10} from three urban locations in New Zealand. *Sci Total Environ*, 349(1–3):161–74. doi:10.1016/j.scitotenv.2005.01.008 PMID:16198678

Buschini A, Cassoni F, Anceschi E, Pasini L, Poli P, Rossi C (2001). Urban airborne particulate: genotoxicity evaluation of different size fractions by mutagenesis tests on microorganisms and comet assay. *Chemosphere*, 44(8):1723–36. doi:10.1016/S0045-6535(00)00550-6 PMID:11534904

Carreras HA, Calderón-Segura ME, Gómez-Arroyo S, Murillo-Tovar MA, Amador-Muñoz O (2013). Composition and mutagenicity of PAHs associated with urban airborne particles in Córdoba, Argentina. *Environ Pollut*, 178:403–10. doi:10.1016/j.envpol.2013.03.016 PMID:23624338

Carreras HA, Pignata ML, Saldiva PHN (2006). In situ monitoring of urban air in Cordoba, Argentina using the *Tradescantia*-micronucleus (Trad-MCN) bioassay. *Atmos Environ*, 40(40):7824–30.

Carreras HA, Rodriguez JH, González CM, Wannaz ED, Garcia Ferreyra F, Perez CA et al. (2009). Assessment of the relationship between total suspended particles and the response of two biological indicators transplanted to an urban area in central Argentina. *Atmos Environ*, 43(18):2944–9. doi:10.1016/j.atmosenv.2009.02.060

Carter JD, Ghio AJ, Samet JM, Devlin RB (1997). Cytokine production by human airway epithelial cells after exposure to an air pollution particle is metal-dependent. *Toxicol Appl Pharmacol*, 146(2):180–8. doi:10.1006/taap.1997.8254 PMID:9344885

Carvalho-Oliveira R, Pozo RM, Lobo DJ, Lichtenfels AJ, Martins-Junior HA, Bustilho JO et al. (2005). Diesel emissions significantly influence composition and mutagenicity of ambient particles: a case study in São Paulo, Brazil. *Environ Res*, 98(1):1–7. doi:10.1016/j.envres.2004.05.007 PMID:15721877

Casellas M, Fernandez P, Bayona JM, Solanas AM (1995). Bioassay-directed chemical analysis of genotoxic components in urban airborne particulate matter from Barcelona (Spain). *Chemosphere*, 30(4):725–40. doi:10.1016/0045-6535(94)00438-Z PMID:7889349

Cassee FR, Boere AJ, Fokkens PH, Leseman DL, Sioutas C, Kooter IM et al. (2005). Inhalation of concentrated particulate matter produces pulmonary inflammation and systemic biological effects in compromised rats. *J Toxicol Environ Health A*, 68(10):773–96. doi:10.1080/15287390590930171 PMID:16020176

Cassoni F, Bocchi C, Martino A, Pinto G, Fontana F, Buschini A (2004). The *Salmonella* mutagenicity of urban airborne particulate matter ($PM_{2.5}$) from eight sites of the Emilia-Romagna regional monitoring network (Italy). *Sci Total Environ*, 324(1–3):79–90. doi:10.1016/j.scitotenv.2003.10.030 PMID:15081698

Cavanagh JA, Trought K, Brown L, Duggan S (2009). Exploratory investigation of the chemical characteristics and relative toxicity of ambient air particulates from two New Zealand cities. *Sci Total Environ*, 407(18):5007–18. doi:10.1016/j.scitotenv.2009.05.020 PMID:19570565

Cerná M, Pastorková A, Vrbíková V, Smíd J, Rössner P (1999). Mutagenicity monitoring of airborne particulate matter (PM_{10}) in the Czech Republic. *Mutat Res*, 444(2):373–86. doi:10.1016/S1383-5718(99)00107-2 PMID:10521677

Cerná M, Pochmanová D, Pastorková A, Benes I, Lenícek J, Topinka J et al. (2000). Genotoxicity of urban air pollutants in the Czech Republic. Part I. Bacterial mutagenic potencies of organic compounds adsorbed on PM_{10} particulates. *Mutat Res*, 469(1):71–82. PMID:10946244

Charrier JG, Anastasio C (2012). On dithiothreitol (DTT) as a measure of oxidative potential for ambient particles: evidence for the importance of soluble transition metals. *Atmos Chem Phys*, 12(5):11317–50. doi:10.5194/acpd-12-11317-2012 PMID:23393494

Che YJ, Liu DM, Dong LX, Yuan YS, Li J, Sun JL (2008). Mutagenicity of PAHs fraction in the PM_{10} and $PM_{2.5}$ collected in Beijing city. *J Environ Health*, 25:1047–9.

Chen ST, Lin CC, Liu YS, Lin C, Hung PT, Jao CW et al. (2013). Airborne particulate collected from central Taiwan induces DNA strand breaks, poly(ADP-ribose) polymerase-1 activation, and estrogen-disrupting activity in human breast carcinoma cell lines. *J Environ Sci Health A Tox Hazard Subst Environ Eng*, 48(2):173–81. doi:10.1080/10934529.2012.717809 PMID:23043339

Chen W, Guo XB (2007). Mutagenicity of organic or inorganic extracts from dust storm or non-dust storm total suspended particulates. *J Toxicol*, 21:120–2.

Chen ZL, Zhu DK, Xu ZQ (1982). Preliminary study of mutagenicity of solvent extract of airborne particulate and its daily variation. *Environ Chem*, 1:267–73.

Chen ZL, Zhu DK, Xu ZQ et al. (1983). Mutagenicity of benzene extracts of airborne particulates and relationship with some pollution indictors. *Environ Chem*, 2(6):32–7.

Chen ZL, Zhu DK, Zu Q et al. (1987). Mutagenicity and chemical components in benzene extract of airborne particulates from Yanshan. *Environ Sci*, 8:10–3.

Cho AK, Sioutas C, Miguel AH, Kumagai Y, Schmitz DA, Singh M et al. (2005). Redox activity of airborne particulate matter at different sites in the Los Angeles Basin. *Environ Res*, 99(1):40–7. doi:10.1016/j.envres.2005.01.003 PMID:16053926

Chou MC, Lee H (1990). Mutagenicity of airborne particles from four cities in Taiwan. *Proc Natl Sci Counc Repub China B*, 14(3):142–50. PMID:1703312

Chroust K, Kuglík P, Relichová J, Holoubek I, Čáslavský J, Veselská R et al. (1997). *Drosophila melanogaster*, *Vicia faba* and *Arabidopsis thaliana* short-term bioassays in genotoxicity evaluation of air and soil samples from sites surrounding two industrial factories in the Czech Republic. *Folia Biol (Praha)*, 43(2):71–8. PMID:9158954

Chung MY, Lazaro RA, Lim D, Jackson J, Lyon J, Rendulic D et al. (2006). Aerosol-borne quinones and reactive oxygen species generation by particulate matter extracts. *Environ Sci Technol*, 40(16):4880–6. doi:10.1021/es0515957 PMID:16955881

Ciganek M, Neca J, Adamec V, Janosek J, Machala M (2004). A combined chemical and bioassay analysis of traffic-emitted polycyclic aromatic hydrocarbons. *Sci Total Environ*, 334–335:141–8. doi:10.1016/j.scitotenv.2004.04.034 PMID:15504500

Clarke RW, Catalano P, Coull B Koutrakis P, Krishna Murthy GG, Rice T et al. (2000a). Age-related responses in rats to concentrated urban air particles (CAPs). *Inhal Toxicol*, 12:73–84. doi:10.1080/089583700196400

Clarke RW, Catalano PJ, Koutrakis P, Murthy GG, Sioutas C, Paulauskis J et al. (1999). Urban air particulate inhalation alters pulmonary function and induces pulmonary inflammation in a rodent model of chronic bronchitis. *Inhal Toxicol*, 11(8):637–56. doi:10.1080/089583799196781 PMID:10477440

Clarke RW, Coull B, Reinisch U, Catalano P, Killingsworth CR, Koutrakis P et al. (2000b). Inhaled concentrated ambient particles are associated with hematologic and bronchoalveolar lavage changes in canines. *Environ Health Perspect*, 108(12):1179–87. doi:10.1289/ehp.001081179 PMID:11133399

Claxton LD, Warren S, Zweidinger R, Creason J (2001). A comparative assessment of Boise, Idaho, ambient air fine particle samples using the plate and microsuspension *Salmonella* mutagenicity assays. *Sci Total Environ*, 275(1–3):95–108. doi:10.1016/S0048-9697(00)00857-3 PMID:11482407

Commoner B, Madyastha R, Bronsdon A, Vithayathil AJ (1978). Environmental mutagens in urban air particulates. *J Toxicol Environ Health*, 4(1):59–77. doi:10.1080/15287397809529645 PMID:633412

Costa DL, Lehmann JR, Winsett D, Richards J, Ledbetter AD, Dreher KL (2006). Comparative pulmonary toxicological assessment of oil combustion particles following inhalation or instillation exposure. *Toxicol Sci*, 91(1):237–46. doi:10.1093/toxsci/kfj123 PMID:16449252

Costa GM, Droste A (2012). Genotoxicity on *Tradescantia pallida* var. *purpurea* plants exposed to urban and rural environments in the metropolitan area of Porto Alegre, southern Brazil. *Braz J Biol*, 72(4):801–6. doi:10.1590/S1519-69842012000500004 PMID:23295507

Courtois Y, Chouroulinkov I, Festy B (1981). Influence of method of sampling of particulate matter in urban air on its genotoxicity for bacteria and animal cells. *Pollut Atmos*, 23(90):109–14.

Courtois YA, Min S, Lachenal C, Jacquot-Deschamps JM, Callais F, Festy B (1988). Genotoxicity of organic extracts from atmospheric particles. *Ann N Y Acad Sci*, 534:724–40. doi:10.1111/j.1749-6632.1988.tb30162.x PMID:3389685

Crebelli R (1989). Monitoring of urban air pollution by mutagenicity assays. *Ann Ist Super Sanita*, 25(4):591–4. PMID:2631625

Crebelli R, Fuselli S, Baldassarri LT, Ziemacki G, Carere A, Benigni R (1995). Genotoxicity of urban air particulate matter: correlations between mutagenicity data, airborne micropollutants, and meteorological parameters. *Int J Environ Health Res*, 5(1):19–34. doi:10.1080/09603129509356830

Crebelli R, Fuselli S, Conti G, Conti L, Carere A (1991). Mutagenicity spectra in bacterial strains of airborne and engine exhaust particulate extracts. *Mutat Res*, 261(4):237–48. doi:10.1016/0165-1218(91)90039-O PMID:1722279

Dagher Z, Garçon G, Billet S, Gosset P, Ledoux F, Courcot D et al. (2006). Activation of different pathways of apoptosis by air pollution particulate matter ($PM_{2.5}$) in human epithelial lung cells (L132) in culture. *Toxicology*, 225(1):12–24. doi:10.1016/j.tox.2006.04.038 PMID:16787692

Daisey JM, Kneip TJ, Hawryluk I, Mukai F (1980). Seasonal variations in the bacterial mutagenicity of airborne particulate organic matter in New York City. *Environ Sci Technol*, 14(12):1487–90. doi:10.1021/es60172a001 PMID:22279993

Danielsen PH, Loft S, Jacobsen NR, Jensen KA, Autrup H, Ravanat JL et al. (2010). Oxidative stress, inflammation, and DNA damage in rats after intratracheal instillation or oral exposure to ambient air and wood smoke particulate matter. *Toxicol Sci*, 118(2):574–85. doi:10.1093/toxsci/kfq290 PMID:20864625

Danielsen PH, Loft S, Kocbach A, Schwarze PE, Møller P (2009). Oxidative damage to DNA and repair induced by Norwegian wood smoke particles in human A549 and THP-1 cell lines. *Mutat Res*, 674(1–2):116–22. doi:10.1016/j.mrgentox.2008.10.014 PMID:19041418

Danielsen PH, Loft S, Møller P (2008). DNA damage and cytotoxicity in type II lung epithelial (A549) cell cultures after exposure to diesel exhaust and urban street particles. *Part Fibre Toxicol*, 5(1):6 doi:10.1186/1743-8977-5-6 PMID:18397523

Danielsen PH, Møller P, Jensen KA, Sharma AK, Wallin H, Bossi R et al. (2011). Oxidative stress, DNA damage, and inflammation induced by ambient air and wood smoke particulate matter in human A549 and THP-1 cell lines. *Chem Res Toxicol*, 24(2):168–84. doi:10.1021/tx100407m PMID:21235221

de Andrade SJ, Varella SD, Pereira GT, Zocolo GJ, de Marchi MR, Varanda EA (2011). Mutagenic activity of airborne particulate matter (PM_{10}) in a sugarcane farming area (Araraquara city, southeast Brazil). *Environ Res*, 111(4):545–50. doi:10.1016/j.envres.2011.03.004 PMID:21481367

De Flora S, Bagnasco M, Izzotti A, D'Agostini F, Pala M, Valerio F (1989). Mutagenicity of polycyclic aromatic hydrocarbon fractions extracted from urban air particulates. *Mutat Res*, 224(2):305–18. doi:10.1016/0165-1218(89)90169-9 PMID:2677712

de Kok TM, Hogervorst JG, Briedé JJ, van Herwijnen MH, Maas LM, Moonen EJ et al. (2005). Genotoxicity and physicochemical characteristics of traffic-related ambient particulate matter. *Environ Mol Mutagen*, 46(2):71–80. doi:10.1002/em.20133 PMID:15880737

de Kok TM, Hogervorst JG, Kleinjans JC, Briedé JJ (2004). Radicals in the church. *Eur Respir J*, 24(6):1069–70. doi:10.1183/09031936.04.00113404 PMID:15572555

De Martinis BS, Kado NY, de Carvalho LR, Okamoto RA, Gundel LA (1999). Genotoxicity of fractionated organic material in airborne particles from São Paulo, Brazil. *Mutat Res*, 446(1):83–94. doi:10.1016/S1383-5718(99)00151-5 PMID:10613188

De Martinis BS, Okamoto RA, Kado NY, Gundel LA, Carvalho LRF (2002). Polycyclic aromatic hydrocarbons in a bioassay-fractionated extract of PM_{10} collected in São Paulo, Brazil. *Atmos Environ*, 36(2):307–14. doi:10.1016/S1352-2310(01)00334-X

de Oliveira Alves N, Matos Loureiro AL, Dos Santos FC, Nascimento KH, Dallacort R, de Castro Vasconcellos P et al. (2011). Genotoxicity and composition of particulate matter from biomass burning in the eastern Brazilian

Amazon region. *Ecotoxicol Environ Saf*, 74(5):1427–33. doi:10.1016/j.ecoenv.2011.04.007 PMID:21496924

de Raat WK (1983). Genotoxicity of aerosol extracts. Some methodological aspects and the contribution of urban and industrial locations. *Mutat Res*, 116(1):47–63. doi:10.1016/0165-1218(83)90005-8 PMID:6298617

de Raat WK, Boers JP, Bakker GL, De Meijere FA, Hooimeijer A, Lohman PHM et al. (1994). Contribution of PAH and some of their nitrated derivatives to the mutagenicity of ambient airborne particles and coal fly ash. *Sci Total Environ*, 153(1–2):7–28. doi:10.1016/0048-9697(94)90098-1 PMID:8016630

de Raat WK, de Meijere FA (1988). The mutagenicity of ambient air particles from local traffic and distant sources during episodes with moderate photochemical air pollution. *Sci Total Environ*, 73(3):159–79. doi:10.1016/0048-9697(88)90426-3 PMID:2463671

de Raat WK, de Meijere FA, Kooijman SALM (1985). Mutagenicity of ambient aerosol collected in an urban and industrial area of The Netherlands. *Sci Total Environ*, 44(1):17–33. doi:10.1016/0048-9697(85)90048-8 PMID:3895434

de Raat WK, Kooijman SA, Gielen JW (1987). Concentrations of polycyclic hydrocarbons in airborne particles in The Netherlands and their correlation with mutagenicity. *Sci Total Environ*, 66:95–114. doi:10.1016/0048-9697(87)90080-5 PMID:3317821

De Vizcaya-Ruiz A, Gutierrez-Castillo ME, Uribe-Ramirez M, Cebrián ME, Mugica-Alvarez V, Sepúlveda J et al. (2006). Characterization and in vitro biological effects of concentrated particulate matter from Mexico City. *Atmos Environ*, 40:Suppl 2: 583–92. doi:10.1016/j.atmosenv.2005.12.073

de Wiest F, Rondia D, Gol-Winkler R, Gielen J (1982). Mutagenic activity of non-volatile organic matter associated with suspended matter in urban air. *Mutat Res*, 104(4–5):201–7. doi:10.1016/0165-7992(82)90145-2 PMID:7050682

Dehnen W, Pitz N, Tomingas R (1978). The mutagenicity of airborne particulate pollutants. *Cancer Lett*, 4(1):5–12. doi:10.1016/S0304-3835(78)93027-6 PMID:342091

Delgado-Rodríguez A, Ortíz-Marttelo R, Villalobos-Pietrini R, Gómez-Arroyo S, Graf U (1999). Genotoxicity of organic extracts of airborne particles in somatic cells of *Drosophila melanogaster*. *Chemosphere*, 39(1):33–43. doi:10.1016/S0045-6535(98)00586-4 PMID:10377966

Dellinger B, Pryor WA, Cueto R, Squadrito GL, Hegde V, Deutsch WA (2001). Role of free radicals in the toxicity of airborne fine particulate matter. *Chem Res Toxicol*, 14(10):1371–7. doi:10.1021/tx010050x PMID:11599928

DeMarini DM, Shelton ML, Bell DA (1994). Mutation spectra in *Salmonella* of complex mixtures: comparison of urban air to benzo[*a*]pyrene. *Environ Mol Mutagen*, 24(4):262–75. doi:10.1002/em.2850240403 PMID:7851338

Dergham M, Lepers C, Verdin A, Billet S, Cazier F, Courcot D et al. (2012). Prooxidant and proinflammatory potency of air pollution particulate matter ($PM_{2.5-0.3}$) produced in rural, urban, or industrial surroundings in human bronchial epithelial cells (BEAS-2B). *Chem Res Toxicol*, 25(4):904–19. doi:10.1021/tx200529v PMID:22404339

Di Pietro A, Visalli G, Munaò F, Baluce B, La Maestra S, Primerano P et al. (2009). Oxidative damage in human epithelial alveolar cells exposed in vitro to oil fly ash transition metals. *Int J Hyg Environ Health*, 212(2):196–208. doi:10.1016/j.ijheh.2008.05.005 PMID:18667355

Dick CA, Singh P, Daniels M, Evansky P, Becker S, Gilmour MI (2003). Murine pulmonary inflammatory responses following instillation of size-fractionated ambient particulate matter. *J Toxicol Environ Health A*, 66(23):2193–207. doi:10.1080/716100636 PMID:14669776

Dieme D, Cabral-Ndior M, Garçon G, Verdin A, Billet S, Cazier F et al. (2012). Relationship between physicochemical characterization and toxicity of fine particulate matter ($PM_{2.5}$) collected in Dakar city (Senegal). *Environ Res*, 113:1–13. doi:10.1016/j.envres.2011.11.009 PMID:22284916

Dimitrova M, Dimova E, Mitrovska Z, Kapchina-Toteva V, Chankova S (2007). Testing of polluted soil samples for genotoxic potential using *Chlamydomonas reinhardtii*. *Algol Stud*, 123(1):111–21. doi:10.1127/1864-1318/2007/0123-0111

Dimitrova M, Mitrovska Z, Kapchina-Toteva V, Dimova E, Chankova S (2009). Testing of polluted air samples for genotoxic potential using *Chlamydomonas reinhardtii*. *C R Acad Bulg Sci*, 62(1):57–62.

Ding GW, Wang XY (1999). The study on the mutagenicity of the organic extracts from ambient total suspended particulates in Lanzhou. *J Environ Health*, 16:96–7.

Donaldson K, Brown DM, Mitchell C, Dineva M, Beswick PH, Gilmour P et al. (1997). Free radical activity of PM_{10}: iron-mediated generation of hydroxyl radicals. *Environ Health Perspect*, 105:Suppl 5:1285–9. PMID:9400739

Du Four VA, Janssen CR, Brits E, Van Larebeke N (2005). Genotoxic and mutagenic activity of environmental air samples from different rural, urban and industrial sites in Flanders, Belgium. *Mutat Res*, 588(2):106–17. doi:10.1016/j.mrgentox.2005.09.007 PMID:16314139

Du Four VA, Van Larebeke N, Janssen CR (2004). Genotoxic and mutagenic activity of environmental air samples in Flanders, Belgium. *Mutat Res*, 558(1–2):155–67. doi:10.1016/j.mrgentox.2003.12.002 PMID:15036129

Dwivedi S, Saquib Q, Al-Khedhairy AA, Ali AY, Musarrat J (2012). Characterization of coal fly ash nanoparticles and induced oxidative DNA damage in human peripheral blood mononuclear cells. *Sci Total Environ*, 437:331–8. doi:10.1016/j.scitotenv.2012.08.004 PMID:22960109

Dybing E, Løvdal T, Hetland RB, Løvik M, Schwarze PE (2004). Respiratory allergy adjuvant and inflammatory effects of urban ambient particles. *Toxicology*, 198(1–3):307–14. doi:10.1016/j.tox.2004.02.007 PMID:15138057

Elassouli SM, Alqahtani MH, Milaat W (2007). Genotoxicity of air borne particulates assessed by comet and the *Salmonella* mutagenicity test in Jeddah, Saudi Arabia. *Int J Environ Res Public Health*, 4(3):216–33. doi:10.3390/ijerph2007030004 PMID:17911660

Endo O, Sugita K, Goto S, Amagai T, Matsushita H (2003). Mutagenicity of size-fractioned airborne particles collected with Andersen low pressure impactor. *J Health Sci*, 49(1):22–7. doi:10.1248/jhs.49.22

Erdinger L, Dörr I, Dürr M, Höpker KA (2004). Analysis of mutagenic activity of airborne particulate matter, standard reference materials and reference compounds using base pair-specific *Salmonella typhimurium* tester strains. *Mutat Res*, 564(2):149–57. doi:10.1016/j.mrgentox.2004.08.002 PMID:15507379

Erdinger L, Dürr M, Höpker KA (2005). Correlations between mutagenic activity of organic extracts of airborne particulate matter, NO_x and sulphur dioxide in southern Germany: results of a two-year study. *Environ Sci Pollut Res Int*, 12(1):10–20. doi:10.1065/espr2004.04.196 PMID:15768736

Espinosa-Aguirre JJ, Reyes RE, Rubio J, Ostrosky-Wegman P, Martinez G (1993). Mutagenic activity of urban air samples and its modulation by chili extracts. *Mutat Res*, 303(2):55–61. doi:10.1016/0165-7992(93)90095-D PMID:7692278

Ezoe Y, Ohkubo T, Ohmori K, Fushiwaki Y, Mori Y, Umeda M et al. (2004). Promoter and mutagenic activity of particulate matter collected from urban air. *J Health Sci*, 50(2):181–4. doi:10.1248/jhs.50.181

Farina F, Sancini G, Mantecca P, Gallinotti D, Camatini M, Palestini P (2011). The acute toxic effects of particulate matter in mouse lung are related to size and season of collection. *Toxicol Lett*, 202(3):209–17. doi:10.1016/j.toxlet.2011.01.031 PMID:21371539

Feilberg A, Nielsen T, Binderup M-L, Skov H, Poulsen MWB (2002). Observations of the effect of atmospheric processes on the genotoxic potency of airborne particulate matter. *Atmos Environ*, 36(29):4617–25. doi:10.1016/S1352-2310(02)00462-4

Ferreira MI, Domingos M, Gomes HA, Saldiva PH, de Assunção JV (2007). Evaluation of mutagenic potential of contaminated atmosphere at Ibirapuera Park, São Paulo - SP, Brazil, using the *Tradescantia* stamen-hair assay. *Environ Pollut*, 145(1):219–24. doi:10.1016/j.envpol.2006.03.013 PMID:16777295

Ferreira MI, Petrenko H, Lobo DJ, Rodrigues GS, Moreira A, Saldiva PH (2000). In situ monitoring of the mutagenic effects of the gaseous emissions of a solid waste incinerator in metropolitan São Paulo, Brazil, using the *Tradescantia* stamen-hair assay. *J Air Waste Manag Assoc*, 50(10):1852–6. doi:10.1080/10473289.2000.10464217 PMID:11288313

Ferreira MI, Rodrigues GS, Domingos M, Saldiva PHDN (2003). In situ monitoring of mutagenicity of air pollutants in São Paulo city using *Tradescantia*-SHM bioassay. *Braz Arch Biol Technol*, 46(2):253–8. doi:10.1590/S1516-89132003000200017

Festy B, Coviaux F, Le Moullec Y, Juguet B, Person A, Courtois Y (1984). Potential toxicity of urban air contamination by inert particles [in French]. *Ann Pharm Fr*, 42(6):519–28. PMID:6535427

Festy LP (1980). Biological activity of organic extracts from atmospheric particles in urban air. *Pollut Atmos*, 22:50–7.

Fitz DR, Lokensgard DM, Doyle GJ (1984). Investigation of filtration artifacts when sampling ambient particulate matter for mutagen assay. *Atmos Environ Part A Gen Top*, 18(1):205–13. doi:10.1016/0004-6981(84)90244-0

Flessel CP, Guirguis GN, Cheng JC, Chang K-I, Hahn ES, Twiss SA et al. (1985). Sources of mutagens in Contra Costa County community aerosols during pollution episodes: diurnal variations and relations to source emissions tracers. *Environ Int*, 11(2–4):293–301. doi:10.1016/0160-4120(85)90021-2

Flessel CP, Wesolowski JJ, Twiss S, Cheng J, Ondo J, Monto N et al. (1980). Integration of the Ames bioassay and chemical analyses in an epidemiological cancer incidence study. In: Waters MD, Sandhu SS, Lewtas J, Claxton LD, Nesnow S, editors. Short-term bioassays in the analysis of complex environmental mixtures II. New York (NY): Springer; pp. 67–83. Available from: http://dx.doi.org/10.1007/978-1-4684-4121-5_5.

Fomin A, Hafner C (1998). Evaluation of genotoxicity of emissions from municipal waste incinerators with *Tradescantia*-micronucleus bioassay (Trad-MCN). *Mutat Res*, 414(1–3):139–48. doi:10.1016/S1383-5718(98)00049-7 PMID:9630577

Frampton MW, Ghio AJ, Samet JM, Carson JL, Carter JD, Devlin RB (1999). Effects of aqueous extracts of PM_{10} filters from the Utah Valley on human airway epithelial cells. *Am J Physiol*, 277(5 Pt 1):L960–7. PMID:10564181

Fujii T, Hayashi S, Hogg JC, Mukae H, Suwa T, Goto Y et al. (2002). Interaction of alveolar macrophages and airway epithelial cells following exposure to particulate matter produces mediators that stimulate the bone marrow. *Am J Respir Cell Mol Biol*, 27(1):34–41. doi:10.1165/ajrcmb.27.1.4787 PMID:12091243

Fujii T, Hayashi S, Hogg JC, Vincent R, Van Eeden SF (2001). Particulate matter induces cytokine expression in human bronchial epithelial cells. *Am J Respir Cell Mol Biol*, 25(3):265–71. doi:10.1165/ajrcmb.25.3.4445 PMID:11588002

Fukino H, Mimura S, Inoue K, Yamane Y (1982). Mutagenicity of airborne particles. *Mutat Res*, 102(3):237–47. doi:10.1016/0165-1218(82)90133-1 PMID:6755233

Funasaka K, Kitano M, Nakama A, Yoshikura T, Oda Y (2003). Detection of genotoxicity of atmospheric particles using a high-throughput microplate *umu*-test system. *Acta Biochim Pol*, 50(1):291–6. PMID:12673371

Fuselli S, Benigni R, Conti L, Carere A, Crebelli R (1995). Volatile organic compounds (VOCs) and air mutagenicity: results of one year monitoring at an urban site. *Int J Environ Health Res*, 5(2):123–32. doi:10.1080/09603129509356840

Gábelová A, Valovicová Z, Lábaj J, Bacová G, Binková B, Farmer PB (2007). Assessment of oxidative DNA damage formation by organic complex mixtures from airborne particles PM_{10}. *Mutat Res*, 620(1–2):135–44. doi:10.1016/j.mrfmmm.2007.03.003 PMID:17403525

Garçon G, Dagher Z, Zerimech F, Ledoux F, Courcot D, Aboukais A et al. (2006). Dunkerque City air pollution particulate matter-induced cytotoxicity, oxidative stress and inflammation in human epithelial lung cells (L132) in culture. *Toxicol In Vitro*, 20(4):519–28. doi:10.1016/j.tiv.2005.09.012 PMID:16298102

Gavett SH, Haykal-Coates N, Highfill JW, Ledbetter AD, Chen LC, Cohen MD et al. (2003). World Trade Center fine particulate matter causes respiratory tract hyperresponsiveness in mice. *Environ Health Perspect*, 111(7):981–91. doi:10.1289/ehp.5931 PMID:12782502

Gerlofs-Nijland ME, Boere AJ, Leseman DL, Dormans JA, Sandström T, Salonen RO et al. (2005). Effects of particulate matter on the pulmonary and vascular system: time course in spontaneously hypertensive rats. *Part Fibre Toxicol*, 2(1):2. doi:10.1186/1743-8977-2-2 PMID:15813961

Gerlofs-Nijland ME, Dormans JA, Bloemen HJ, Leseman DL, John A, Boere F et al. (2007). Toxicity of coarse and fine particulate matter from sites with contrasting traffic profiles. *Inhal Toxicol*, 19(13):1055–69. doi:10.1080/08958370701626261 PMID:17957546

Ghio AJ, Devlin RB (2001). Inflammatory lung injury after bronchial instillation of air pollution particles. *Am J Respir Crit Care Med*, 164(4):704–8. doi:10.1164/ajrccm.164.4.2011089 PMID:11520740

Ghio AJ, Stonehuerner J, Dailey LA, Carter JD (1999). Metals associated with both the water-soluble and insoluble fractions of an ambient air pollution particle catalyze an oxidative stress. *Inhal Toxicol*, 11(1):37–49. doi:10.1080/089583799197258 PMID:10380158

Ghio AJ, Suliman HB, Carter JD, Abushamaa AM, Folz RJ (2002). Overexpression of extracellular superoxide dismutase decreases lung injury after exposure to oil fly ash. *Am J Physiol Lung Cell Mol Physiol*, 283(1):L211–8. doi:10.1152/ajplung.00409.2001 PMID:12060579

Gil L, Cáceres D, Adonis M (1997). Influence of atmospheric air pollution on indoor air quality: comparison of chemical pollutants and mutagenicity levels in Santiago (Chile). *Indoor Built Environ*, 6(6):320–30. doi:10.1177/1420326X9700600602

Gil LD, Adonis MI (1996). Polycyclic aromatic hydrocarbon levels and mutagenic activities of organic extracts from airborne particles in Santiago de Chile. *Indoor Built Environ*, 5(3):155–64. doi:10.1177/1420326X9600500306

Gilli G, Pignata C, Schilirò T, Bono R, La Rosa A, Traversi D (2007a). The mutagenic hazards of environmental $PM_{2.5}$ in Turin. *Environ Res*, 103(2):168–75. doi:10.1016/j.envres.2006.08.006 PMID:17007834

Gilli G, Traversi D, Rovere R, Pignata C, Schilirò T (2007b). Chemical characteristics and mutagenic activity of PM_{10} in Torino, a northern Italian city. *Sci Total Environ*, 385(1–3):97–107. doi:10.1016/j.scitotenv.2007.07.006 PMID:17698169

Gilli G, Traversi D, Rovere R, Pignata C, Schilirò T (2007c). Airborne particulate matter: ionic species role in different Italian sites. *Environ Res*, 103(1):1–8. doi:10.1016/j.envres.2006.06.005 PMID:16889767

Gilmour PS, Brown DM, Lindsay TG, Beswick PH, MacNee W, Donaldson K (1996). Adverse health effects of PM_{10} particles: involvement of iron in generation of hydroxyl radical. *Occup Environ Med*, 53(12):817–22. doi:10.1136/oem.53.12.817 PMID:8994401

Goldsmith CA, Frevert C, Imrich A, Sioutas C, Kobzik L (1997). Alveolar macrophage interaction with air pollution particulates. *Environ Health Perspect*, 105:Suppl 5: 1191–5. doi:10.1289/ehp.97105s51191 PMID:9400722

Goldsmith CA, Imrich A, Danaee H, Ning YY, Kobzik L (1998). Analysis of air pollution particulate-mediated oxidant stress in alveolar macrophages. *J Toxicol Environ Health A*, 54(7):529–45. doi:10.1080/009841098158683 PMID:9726778

Gordon T, Nadziejko C, Schlesinger R, Chen LC (1998). Pulmonary and cardiovascular effects of acute exposure to concentrated ambient particulate matter in rats. *Toxicol Lett*, 96–97(1–2):285–8. doi:10.1016/S0378-4274(98)00084-8 PMID:9820679

Goto S, Kato Y, Orii A (1982). Daily variation of mutagenicities of airborne particulates. *J Jpn Soc Air Pollut*, 17:295–303.

Gottlieb A, Schleibinger H, Ketseridis G, Wullenweber M (1983). Mutagenicity of three organic fractions of suspended particulate matter and gas chromatographic analysis of basic azaheterocyclic compounds. *Zentralbl Bakteriol Mikrobiol Hyg B*, 177(1–2):75–89.

Greenberg A, Lwo J, Antherholt TB, Rosen R, Hartman T, Butler J et al. (1993). Bioassay-directed fractionation of organic compounds associated with airborne particulate matter: an interseasonal study. *Atmos Environ Part A Gen Top*, 27(10):1609–26. doi:10.1016/0960-1686(93)90160-Z

Greenwell LL, Moreno T, Jones TP, Richards RJ (2002). Particle-induced oxidative damage is ameliorated by pulmonary antioxidants. *Free Radic Biol Med*, 32(9):898–905. doi:10.1016/S0891-5849(02)00782-7 PMID:11978491

Gualtieri M, Ovrevik J, Mollerup S, Asare N, Longhin E, Dahlman HJ et al. (2011). Airborne urban particles (Milan winter-$PM_{2.5}$) cause mitotic arrest and cell death: effects on DNA, mitochondria, AhR binding and spindle organization. *Mutat Res*, 713(1–2):18–31. doi:10.1016/j.mrfmmm.2011.05.011 PMID:21645525

Guimarães ET, Domingos M, Alves ES, Caldini N Jr, Lobo DJ, Lichtenfels AJ et al. (2000). Detection of the genotoxicity of air pollutants in and around the city of São Paulo (Brazil) with the *Tradescantia*-micronucleus (Trad-MCN) assay. *Environ Exp Bot*, 44(1):1–8. doi:10.1016/S0098-8472(00)00050-2 PMID:10927123

Guimarães ET, Macchione M, Lobo DJ, Domingos M, Saldiva PH (2004). Evaluation of the mutagenic potential of urban air pollution in São Paulo, Southeastern Brazil, using the *Tradescantia* stamen-hair assay. *Environ Toxicol*, 19(6):578–84. doi:10.1002/tox.20065 PMID:15526269

Gundel LA, Dalsey JM, De Carvalho LRF, Kado NY, Schuetzle D (1993). Polar organic matter in airborne particles: chemical characterization and mutagenic activity. *Environ Sci Technol*, 27(10):2112–9. doi:10.1021/es00047a017

Gupta P, Harger WP, Arey J (1996). The contribution of nitro- and methylnitronaphthalenes to the vapor-phase mutagenicity of ambient air samples. *Atmos Environ*, 30(18):3157–66. doi:10.1016/1352-2310(96)00024-6

Halatek T, Stepnik M, Stetkiewicz J, Krajnow A, Kur B, Szymczak W et al. (2011). The inflammatory response in lungs of rats exposed on the airborne particles collected during different seasons in four European cities. *J Environ Sci Health A Tox Hazard Subst Environ Eng*, 46(13):1469–81. doi:10.1080/10978526.2011.609064 PMID:21961642

Hamers T, van Schaardenburg MD, Felzel EC, Murk AJ, Koeman JH (2000). The application of reporter gene assays for the determination of the toxic potency of diffuse air pollution. *Sci Total Environ*, 262(1–2):159–74. doi:10.1016/S0048-9697(00)00600-8 PMID:11059851

Hannigan MP, Busby WF Jr, Cass GR (2005). Source contributions to the mutagenicity of urban particulate air pollution. *J Air Waste Manag Assoc*, 55(4):399–410. doi:10.1080/10473289.2005.10464633 PMID:15887882

Hannigan MP, Cass GR, Lafleur AL, Busby WF Jr, Thilly WG (1996). Seasonal and spatial variation of the bacterial mutagenicity of fine organic aerosol in southern California. *Environ Health Perspect*, 104(4):428–36. doi:10.1289/ehp.96104428 PMID:8732954

Hannigan MP, Cass GR, Lafleur AL, Longwell JP, Thilly WG (1994). Bacterial mutagenicity of urban organic aerosol sources in comparison to atmospheric samples. *Environ Sci Technol*, 28(12):2014–24. doi:10.1021/es00061a009 PMID:22191740

Hansen AM, Wallin H, Binderup ML, Dybdahl M, Autrup H, Loft S et al. (2004). Urinary 1-hydroxypyrene and mutagenicity in bus drivers and mail carriers exposed to urban air pollution in Denmark. *Mutat Res*, 557(1):7–17. doi:10.1016/j.mrgentox.2003.09.007 PMID:14706514

Hanzalova K, Rossner P Jr, Sram RJ (2010). Oxidative damage induced by carcinogenic polycyclic aromatic hydrocarbons and organic extracts from urban air particulate matter. *Mutat Res*, 696(2):114–21. doi:10.1016/j.mrgentox.2009.12.018 PMID:20079458

Happo MS, Salonen RO, Hälinen AI, Jalava PI, Pennanen AS, Kosma VM et al. (2007). Dose and time dependency of inflammatory responses in the mouse lung to urban air coarse, fine, and ultrafine particles from six European cities. *Inhal Toxicol*, 19(3):227–46. doi:10.1080/08958370601067897 PMID:17365027

Hayakawa K, Kawaguchi Y, Murahashi T, Miyazaki M (1995). Distributions of nitropyrenes and mutagenicity in airborne particulates collected with an Andersen sampler. *Mutat Res*, 348(2):57–61. doi:10.1016/0165-7992(95)00046-1 PMID:7477052

Healey K, Lingard JJ, Tomlin AS, Hughes A, White KL, Wild CP et al. (2005). Genotoxicity of size-fractionated samples of urban particulate matter. *Environ Mol Mutagen*, 45(4):380–7. doi:10.1002/em.20105 PMID:15662658

Heidenfelder BL, Reif DM, Harkema JR, Cohen Hubal EA, Hudgens EE, Bramble LA et al. (2009). Comparative microarray analysis and pulmonary changes in Brown Norway rats exposed to ovalbumin and concentrated air particulates. *Toxicol Sci*, 108(1):207–21. doi:10.1093/toxsci/kfp005 PMID:19176365

Hemminki K, Zhang LF, Krüger J, Autrup H, Törnqvist M, Norbeck HE (1994). Exposure of bus and taxi drivers to urban air pollutants as measured by DNA and protein adducts. *Toxicol Lett*, 72(1–3):171–4. doi:10.1016/0378-4274(94)90025-6 PMID:7515516

Hetland RB, Cassee FR, Låg M, Refsnes M, Dybing E, Schwarze PE (2005). Cytokine release from alveolar macrophages exposed to ambient particulate matter: heterogeneity in relation to size, city and season. *Part Fibre Toxicol*, 2(1):4. doi:10.1186/1743-8977-2-4 PMID:16105184

Heussen GA (1991). Inhibition of intercellular communication by airborne particulate matter. *Arch Toxicol*, 65(3):252–6. doi:10.1007/BF02307317 PMID:2053852

Heussen GA, Post JG, Alink GM (1990). Genotoxicity of benzo[*a*]pyrene, 2-nitrofluorene and airborne particulates in the DNA-repair host-mediated assay. *Mutat Res*, 241(1):83–93. doi:10.1016/0165-1218(90)90111-E PMID:2185422

Heussen GAH, Alink GM (1990). The use of the DNA repair host mediated assay for the detection of genotoxic activity of benzo[a]pyrene, 2-nitrofluorene and airborne particles in vivo. In: Seemayer NH, Hadnagy W, editors. Environmental hygiene II. Berlin, Germany: Springer-Verlag; pp. 22–5. Available from: http://dx.doi.org/10.1007/978-3-642-46712-7_5.

Hoffmann D, Norpoth K, Wickramasinghe RH, Müller G (1980). The detection of mutagenic air pollutants from filter samples by the *Salmonella*/Mammalian S-9 mutagenicity test (Ames test) with *S. typhimurium* TA 98 (Part 1). *Zentralbl Bakteriol Mikrobiol Hyg B*, 171(4–5):388–407. PMID:7006269

Hogervorst JG, de Kok TM, Briedé JJ, Wesseling G, Kleinjans JC, van Schayck CP (2006). Relationship between radical generation by urban ambient particulate matter and pulmonary function of school children. *J Toxicol Environ Health A*, 69(3–4):245–62. doi:10.1080/15287390500227431 PMID:16263695

Hoogendoorn B, Berube K, Gregory C, Jones T, Sexton K, Brennan P et al. (2012). Gene and protein responses of human lung tissue explants exposed to ambient particulate matter of different sizes. *Inhal Toxicol*, 24(14):966–75. doi:10.3109/08958378.2012.742600 PMID:23216157

Hosgood HD 3rd, Berndt SI, Lan Q (2007). GST genotypes and lung cancer susceptibility in Asian populations with indoor air pollution exposures: a meta-analysis. *Mutat Res*, 636(1–3):134–43. doi:10.1016/j.mrrev.2007.02.002 PMID:17428724

Houk VS, Goto S, Endo O, Claxton LD, Lewtas J, Matsushita H (1992). Detection of direct-acting mutagens in ambient air: a comparison of two highly sensitive mutagenicity assays. *Environ Mol Mutagen*, 20(1):19–28. doi:10.1002/em.2850200105 PMID:1639079

Hoyer ME, Keeler GJ, Ball JC (1992). Detection of oxidative mutagens in an urban air-particulate extract: a preliminary study. *Mutat Res*, 283(4):295–9. doi:10.1016/0165-7992(92)90062-M PMID:1383803

Hu SK, Yang WM (1988). Mutagenicity of organic chemicals in airborne particles in Kunming. *Yunnan Environ Prot*, 1:66–8.

Huang YC, Karoly ED, Dailey LA, Schmitt MT, Silbajoris R, Graff DW et al. (2011). Comparison of gene expression profiles induced by coarse, fine, and ultrafine particulate matter. *J Toxicol Environ Health A*, 74(5):296–312. doi:10.1080/15287394.2010.516238 PMID:21240730

Hwang YJ, Jeung YS, Seo MH, Yoon JY, Kim DY, Park JW et al. (2010). Asian dust and titanium dioxide particles-induced inflammation and oxidative DNA damage in C57BL/6 mice. *Inhal Toxicol*, 22(13):1127–33. PMID:21070184

Ichinose T, Yoshida S, Sadakane K, Takano H, Yanagisawa R, Inoue K et al. (2008). Effects of Asian sand dust, Arizona sand dust, amorphous silica and aluminum oxide on allergic inflammation in the murine lung. *Inhal Toxicol*, 20(7):685–94. doi:10.1080/08958370801935133 PMID:18464056

Ieradi LA, Cristaldi M, Mascanzoni D, Cardarelli E, Grossi R, Campanella L (1996). Genetic damage in urban mice exposed to traffic pollution. *Environ Pollut*, 92(3):323–8. doi:10.1016/0269-7491(95)00109-3 PMID:15091385

Imrich A, Ning Y, Lawrence J, Coull B, Gitin E, Knutson M et al. (2007). Alveolar macrophage cytokine response to air pollution particles: oxidant mechanisms. *Toxicol Appl Pharmacol*, 218(3):256–64. doi:10.1016/j.taap.2006.11.033 PMID:17222881

Imrich A, Ning YY, Koziel H, Coull B, Kobzik L (1999). Lipopolysaccharide priming amplifies lung macrophage tumor necrosis factor production in response to air particles. *Toxicol Appl Pharmacol*, 159(2):117–24. doi:10.1006/taap.1999.8731 PMID:10495775

Isidori M, Ferrara M, Lavorgna M, Nardelli A, Parrella A (2003). In situ monitoring of urban air in Southern Italy with the *Tradescantia* micronucleus bioassay and semipermeable membrane devices (SPMDs). *Chemosphere*, 52(1):121–6. doi:10.1016/S0045-6535(03)00183-8 PMID:12729694

Israël GW, Busing JB (1983). Investigations on the mutagenic action of urban particulates. *J Aerosol Sci*, 14(3):192–4. doi:10.1016/0021-8502(83)90025-3

Israel GW, Freise R, Busing J (1984). Mutagenic activity and composition of organic particulates from domestic heating and automobile traffic. In: Liu BYH, Pui DYH, Fissen HJ, editors. Aerosols: science, technology, and industrial applications of airborne particles. New York (NY): Elsevier Science; pp. 261–4.

Iwado H, Koyano M, Goto S, Kira S, Hayatsu H (1994). Ubiquitous presence of mutagenic and antimutagenic components in air-borne particulates of two Japanese cities. *Mutat Res*, 322(4):329–39. doi:10.1016/0165-1218(94)90109-0 PMID:7523927

Iwado H, Naito M, Hayatsu H (1991). Mutagenicity and antimutagenicity of air-borne particulates. *Mutat Res*, 246(1):93–102. doi:10.1016/0027-5107(91)90110-A PMID:1986270

Izzotti A, Camoirano A, D'Agostini F, Sciacca S, De Naro Papa F, Cesarone CF et al. (1996). Biomarker alterations produced in rat lung by intratracheal instillations of air particulate extracts and chemoprevention with oral *N*-acetylcysteine. *Cancer Res*, 56(7):1533–8. PMID:8603398

Jadczyk P, Kucharczyk J (2000). Seasonal variability of the mutagenicity of airborne particles for *Salmonella typhimurium* TA 98 and *Saccharomyces cerevisiae* XV 185-14C. *Environ Prot Eng*, 26(1):89–102.

Jadczyk P, Kucharczyk J (2005). Mutagenicity of pollutants and their fractions adsorbed on airborne particulate in the centre of Wrocław (Poland). *Environ Prot Eng*, 31(2):77–92.

Jalava P, Salonen RO, Hälinen AI, Sillanpää M, Sandell E, Hirvonen MR (2005). Effects of sample preparation on chemistry, cytotoxicity, and inflammatory responses induced by air particulate matter. *Inhal Toxicol*, 17(2):107–17. doi:10.1080/08958370590899550 PMID:15764488

Jalava PI, Salonen RO, Pennanen AS, Sillanpää M, Hälinen AI, Happo MS et al. (2007). Heterogeneities in inflammatory and cytotoxic responses of RAW 264.7 macrophage cell line to urban air coarse, fine, and ultrafine particles from six European sampling campaigns. *Inhal Toxicol*, 19(3):213–25. doi:10.1080/08958370601067863 PMID:17365026

Jeng HA (2010). Chemical composition of ambient particulate matter and redox activity. *Environ Monit Assess*, 169(1–4):597–606. doi:10.1007/s10661-009-1199-8 PMID:19902370

Jiang L, Dai H, Sun Q, Geng C, Yang Y, Wu T et al. (2011). Ambient particulate matter on DNA damage in HepG2 cells. *Toxicol Ind Health*, 27(1):87–95. doi:10.1177/0748233710387001 PMID:20947658

Kado NY, Guirguis GN, Flessel CP, Chan RC, Chang KI, Wesolowski JJ (1986). Mutagenicity of fine (less than 2.5 microns) airborne particles: diurnal variation in community air determined by a *Salmonella* micro preincubation (microsuspension) procedure. *Environ Mutagen*, 8(1):53–66. doi:10.1002/em.2860080106 PMID:3510862

Kamdar O, Le W, Zhang J, Ghio AJ, Rosen GD, Upadhyay D (2008). Air pollution induces enhanced mitochondrial oxidative stress in cystic fibrosis airway epithelium. *FEBS Lett*, 582(25–26):3601–6. doi:10.1016/j.febslet.2008.09.030 PMID:18817777

Kameda T, Inazu K, Bandow H, Sanukida S, Maeda Y (2004). Diurnal change of direct-acting mutagenicity of soluble organic fraction of airborne particles collected at Southern Osaka: correlation between the mutagenicity, particles-associated nitroarenes, and gaseous emission. *Atmos Environ*, 38(13):1903–12. doi:10.1016/j.atmosenv.2004.01.007

Karlsson HL, Holgersson A, Möller L (2008). Mechanisms related to the genotoxicity of particles in the subway and from other sources. *Chem Res Toxicol*, 21(3):726–31. doi:10.1021/tx7003568 PMID:18260651

Karlsson HL, Ljungman AG, Lindbom J, Möller L (2006). Comparison of genotoxic and inflammatory effects of particles generated by wood combustion, a road simulator and collected from street and subway. *Toxicol Lett*, 165(3):203–11. doi:10.1016/j.toxlet.2006.04.003 PMID:16716543

Karlsson HL, Nilsson L, Möller L (2005). Subway particles are more genotoxic than street particles and induce oxidative stress in cultured human lung cells. *Chem Res Toxicol*, 18(1):19–23. doi:10.1021/tx049723c PMID:15651844

Karlsson HL, Nygren J, Möller L (2004). Genotoxicity of airborne particulate matter: the role of cell-particle interaction and of substances with adduct-forming and oxidizing capacity. *Mutat Res*, 565(1):1–10. doi:10.1016/j.mrgentox.2004.07.015 PMID:15576234

Kawanaka Y, Matsumoto E, Sakamoto K, Wang N, Yun S-J (2004). Size distributions of mutagenic compounds and mutagenicity in atmospheric particulate matter collected with a low-pressure cascade impactor. *Atmos Environ*, 38(14):2125–32. doi:10.1016/j.atmosenv.2004.01.021

Kawanaka Y, Matsumoto E, Wang N, Tsuchiya Y, Yun S-J, Zhao WJ et al. (2006). Mutagenic activity of atmospheric ultrafine particles at a roadside site and a suburban site. *J Health Sci*, 52(4):352–7. doi:10.1248/jhs.52.352

Kawanaka Y, Matsumoto E, Sakamoto K, Yun SJ (2011). Estimation of the contribution of ultrafine particles to lung deposition of particle-bound mutagens in the atmosphere. *Sci Total Environ*, 409(6):1033–8. doi:10.1016/j.scitotenv.2010.11.035 PMID:21194730

Kawanaka Y, Matsumoto E, Wang N, Yun S-J, Sakamoto K (2008). Contribution of nitrated polycyclic aromatic hydrocarbons to the mutagenicity of ultrafine particles in the roadside atmosphere. *Atmos Environ*, 42(32):7423–8.

Klumpp A, Ansel W, Klumpp G, Calatayud V, Garrec JP, He S et al. (2006). *Tradescantia* micronucleus test indicates genotoxic potential of traffic emissions in European cities. *Environ Pollut*, 139(3):515–22. doi:10.1016/j.envpol.2005.05.021 PMID:16098647

Knaapen AM, Shi T, Borm PJA, Schins RPF (2002). Soluble metals as well as the insoluble particle fraction are involved in cellular DNA damage induced by particulate matter. *Mol Cell Biochem*, 234-235(1–2):317–26. doi:10.1023/A:1015970023889 PMID:12162450

Knudsen LE, Norppa H, Gamborg MO, Nielsen PS, Okkels H, Soll-Johanning H et al. (1999). Chromosomal aberrations in humans induced by urban air pollution: influence of DNA repair and polymorphisms of glutathione *S*-transferase M1 and *N*-acetyltransferase 2. *Cancer Epidemiol Biomarkers Prev*, 8(4 Pt 1):303–10. PMID:10207633

Kocbach A, Namork E, Schwarze PE (2008). Pro-inflammatory potential of wood smoke and traffic-derived particles in a monocytic cell line. *Toxicology*, 247(2–3):123–32. doi:10.1016/j.tox.2008.02.014 PMID:18406506

Kodama Y, Arashidani K, Yoshikawa M, Matsuno K, Fukunaga M (1983). Air pollution survey in Kitakyushu district [in Japanese]. *J UOEH*, 5(4):449–60. PMID:6679652

Kodavanti UP, Mebane R, Ledbetter A, Krantz T, McGee J, Jackson MC et al. (2000). Variable pulmonary responses from exposure to concentrated ambient air particles in a rat model of bronchitis. *Toxicol Sci*, 54(2):441–51. doi:10.1093/toxsci/54.2.441 PMID:10774827

Kong XH, Wang H, Xiao ZX, Chu JH, Yin XJ (1995). A study on mutagenicity of NO_2-PAHs in airborne particulates in different function districts in Shenyang. *J Environ Health*, 12:104–6.

Kong XH, Yi XJ, Wang H (1994). A study on mutagenicity of NO_2-PAHs in airborne particulates in Shenyang. *J Health Toxicol*, 8:160–3.

Kooter I, Pennings J, Opperhuizen A, Cassee F (2005). Gene expression pattern in spontaneously hypertensive rats exposed to urban particulate matter (EHC-93). *Inhal Toxicol*, 17(1):53–65. doi:10.1080/08958370590885717 PMID:15764483

Kooter IM, Boere AJ, Fokkens PH, Leseman DL, Dormans JA, Cassee FR (2006). Response of spontaneously hypertensive rats to inhalation of fine and ultrafine particles from traffic: experimental controlled study. *Part Fibre Toxicol*, 3(1):7 doi:10.1186/1743-8977-3-7 PMID:16700918

Koshy L, Jones T, BéruBé K (2009). Characterization and bioreactivity of respirable airborne particles from a municipal landfill. *Biomarkers*, 14:Suppl 1:49–53. doi:10.1080/13547500902965351 PMID:19604059

Koyano M, Endo O, Katoh M, Valdivia R, Ilabaca Marileo M, Morita K et al. (2002). Polynuclear aromatic hydrocarbon concentration and mutagenicity of airborne particles in urban air: comparison of Tokyo area and Santiago. *J Health Sci*, 48(3):256–62. doi:10.1248/jhs.48.256

Krishna G, Nath J, Ong T (1984). Correlative genotoxicity studies of airborne particles in *Salmonella typhimurium* and cultured human lymphocytes. *Environ Mutagen*, 6(4):585–92. doi:10.1002/em.2860060411 PMID:6381042

Krishna G, Nath J, Soler L, Ong T (1986). Comparative in vivo and in vitro genotoxicity studies of airborne particle extract in mice. *Mutat Res*, 171(2–3):157–63. doi:10.1016/0165-1218(86)90049-2 PMID:3528836

Krishna G, Ong T, Whong WZ, Nath J (1983). Mutagenicity studies of ambient airborne particles. I. Comparison of solvent systems. *Mutat Res*, 124(2):113–20. doi:10.1016/0165-1218(83)90171-4 PMID:6358884

Künzli N, Mudway IS, Götschi T, Shi T, Kelly FJ, Cook S et al. (2006). Comparison of oxidative properties, light absorbance, total and elemental mass concentration of ambient $PM_{2.5}$ collected at 20 European sites. *Environ Health Perspect*, 114(5):684–90. doi:10.1289/ehp.8584 PMID:16675421

Kuo CY, Cheng YW, Chen CY, Lee H (1998). Correlation between the amounts of polycyclic aromatic hydrocarbons and mutagenicity of airborne particulate samples from Taichung City, Taiwan. *Environ Res*, 78(1):43–9. doi:10.1006/enrs.1998.3838 PMID:9630444

Kure EH, Andreassen A, Ovrebø S, Grzybowska E, Fiala Z, Strózyk M et al. (1997). Benzo(a)pyrene-albumin adducts in humans exposed to polycyclic aromatic hydrocarbons in an industrial area of Poland. *Occup Environ Med*, 54(9):662–6. doi:10.1136/oem.54.9.662 PMID:9423579

Lauer FT, Mitchell LA, Bedrick E, McDonald JD, Lee WY, Li WW et al. (2009). Temporal-spatial analysis of U.S.-Mexico border environmental fine and coarse PM air sample extract activity in human bronchial epithelial cells. *Toxicol Appl Pharmacol*, 238(1):1–10. doi:10.1016/j.taap.2009.04.021 PMID:19410595

Lazarová M, Slamenová D (2004). Genotoxic effects of a complex mixture adsorbed onto ambient air particles on human cells in vitro; the effects of vitamins E and C. *Mutat Res*, 557(2):167–75. doi:10.1016/j.mrgentox.2003.10.011 PMID:14729371

Lee H, Law SM, Lin ST (1991). The effect of extraction solvent on the mutagenicity of airborne particles. *Toxicol Lett*, 58(1):59–67. doi:10.1016/0378-4274(91)90191-8 PMID:1897007

Lee H, Su SY, Liu KS, Chou MC (1994). Correlation between meteorological conditions and mutagenicity of airborne particulate samples in a tropical monsoon climate area from Kaohsiung City, Taiwan. *Environ Mol Mutagen*, 23(3):200–7. doi:10.1002/em.2850230309 PMID:8162895

Legostaeva TB, Ingel' FI, Antipanova NA, Iurchenko VV, Iuretseva NA, Kotliar NN (2010). Hygienic evaluation of the total mutagenic activity of snow samples from Magnitogorsk [in Russian]. *Gig Sanit*, (4):47–52. PMID:20873386

Legzdins AE, McCarry BE, Marvin CH, Bryant DW (1995). Methodology for bioassay-directed fractionation studies of air particulate material and other complex environmental matrices. *Int J Environ Anal Chem*, 60(2–4):79–94. doi:10.1080/03067319508042866

Lei XF, Wang L, Xun Z (1993). Study of the genocoxicity and concentrtion of five metals in airborne particles. *Chin J Environ Sci*, 14:30–3.

Lei XF, Xing Q (1993). The genotoxicity of air particles with various sizes tested by SOS chromotest. *Chin J Prev Med*, 27:141–3.

Lemos AT, Coronas MV, Rocha JAV, Vargas VMF (2012). Mutagenicity of particulate matter fractions in areas under the impact of urban and industrial activities. *Chemosphere*, 89(9):1126–34. doi:10.1016/j.chemosphere.2012.05.100 PMID:22795069

Li CL, Fu JM, Sheng GY, Bi X, Hao Y, Wang X et al. (2005). Vertical distribution of PAHs in the indoor and outdoor $PM_{2.5}$ in Guangzhou, China. *Build Environ*, 40(3):329–41. doi:10.1016/j.buildenv.2004.05.015

Li J, Wang FL, Ding T (1987). Mutagenicity and cytotoxicity induced by organic extract of airborne particulates. *Acta Academiae Medicinae Shandong*, 25:47–50.

Li N, Sioutas C, Cho A, Schmitz D, Misra C, Sempf J et al. (2003). Ultrafine particulate pollutants induce oxidative stress and mitochondrial damage. *Environ Health Perspect*, 111(4):455–60. doi:10.1289/ehp.6000 PMID:12676598

Li XM, Yu SY, Li J, Chen XM, Jiang LJ, Qu M (1985). Mutagenicity of airborne particles in five big cities in China. *J Hyg Res*, 14:23–6.

Li Z, Hyseni X, Carter JD, Soukup JM, Dailey LA, Huang YC (2006). Pollutant particles enhanced H_2O_2 production from NAD(P)H oxidase and mitochondria in human pulmonary artery endothelial cells. *Am J Physiol Cell Physiol*, 291(2):C357–65. doi:10.1152/ajpcell.00365.2005 PMID:16571865

Líbalová H, Uhlířová K, Kléma J, Machala M, Šrám RJ, Ciganek M et al. (2012). Global gene expression changes in human embryonic lung fibroblasts induced by organic extracts from respirable air particles. *Part Fibre Toxicol*, 9(1):1. doi:10.1186/1743-8977-9-1 PMID:22239852

Lindbom J, Gustafsson M, Blomqvist G, Dahl A, Gudmundsson A, Swietlicki E et al. (2007). Wear particles generated from studded tires and pavement induces inflammatory reactions in mouse macrophage cells. *Chem Res Toxicol*, 20(6):937–46. doi:10.1021/tx700018z PMID:17516662

Lingard JJN, Tomlin AS, Clarke AG, Healey K, Hay AWM, Wild CP et al. (2005). A study of trace metal concentration of urban airborne particulate matter and its role in free radical activity as measured by plasmid strand break assay. *Atmos Environ*, 39(13):2377–84. doi:10.1016/j.atmosenv.2004.05.063

Ljubimova JY, Kleinman MT, Karabalin NM, Inoue S, Konda B, Gangalum P et al. (2013). Gene expression changes in rat brain after short and long exposures to particulate matter in Los Angeles basin air: comparison with human brain tumors. *Exp Toxicol Pathol*, 65(7–8):1063–71. doi:10.1016/j.etp.2013.04.002 PMID:23688656

Löfroth G, Lazaridis G, Agurell E (1985). The use of the *Salmonella*/microsome mutagenicity test for the characterization of organic extracts from ambient air particulate matter. *Environ Int*, 11(2–4):161–7. doi:10.1016/0160-4120(85)90009-1

Loft S, Poulsen HE, Vistisen K, Knudsen LE (1999). Increased urinary excretion of 8-oxo-2′-deoxyguanosine, a biomarker of oxidative DNA damage, in urban bus drivers. *Mutat Res*, 441(1):11–9. doi:10.1016/S1383-5718(99)00034-0 PMID:10224318

Long CM, Suh HH, Kobzik L, Catalano PJ, Ning YY, Koutrakis P (2001). A pilot investigation of the relative toxicity of indoor and outdoor fine particles: in vitro effects of endotoxin and other particulate properties. *Environ Health Perspect*, 109(10):1019–26. doi:10.1289/ehp.011091019 PMID:11689347

Longhin E, Pezzolato E, Mantecca P, Holme JA, Franzetti A, Camatini M et al. (2013). Season linked responses to fine and quasi-ultrafine Milan PM in cultured cells. *Toxicol In Vitro*, 27(2):551–9. doi:10.1016/j.tiv.2012.10.018 PMID:23159502

Lu CH, Wang ZM, Li JM (1990). Preliminary test of SOS/*umu* method for detection of genotoxic agents in air particulates. *Act Academiae Medicinae Shanghai*, 17:221–3.

Lu SZ, Lin J, Ma T (1997). The cell transformation colony test and SOS chromotest for detecting the mutagenic potentials of organic pollutants in the ambient air. *Carcinog, Teratog Mutagen*, 9:145–50.

Lu WG, Zhuo JB, Wang J, Zang ZY (1989). Mutagenic study on organic extractive matter from the air and the drinking water in Chongqing. *Chongqing Environ Sci*, 11:31–5.

Madsen ES, Nielsen PA, Pedersen JC (1982). The distribution and origin of mutagens in airborne particulates, detected by the *Salmonella*/microsome assay in relation to levels of lead, vanadium and PAH. *Sci Total Environ*, 24(1):13–25. doi:10.1016/0048-9697(82)90054-7 PMID:6180475

Mahadevan B, Keshava C, Musafia-Jeknic T, Pecaj A, Weston A, Baird WM (2005). Altered gene expression patterns in MCF-7 cells induced by the urban dust particulate complex mixture standard reference material 1649a. *Cancer Res*, 65(4):1251–8. doi:10.1158/0008-5472.CAN-04-2357 PMID:15735009

Manuguerra M, Matullo G, Veglia F, Autrup H, Dunning AM, Garte S et al. (2007). Multi-factor dimensionality reduction applied to a large prospective investigation on gene-gene and gene-environment interactions. *Carcinogenesis*, 28(2):414–22. doi:10.1093/carcin/bgl159 PMID:16956909

Mao DJ, Shi YM, Zhou YF,, Ding DH, Ma YS, Peng LH et al. (1993). The study of sperm abnormality in mice exposed to organic extracts of total suspended particulates in Shanghai. *Carcinog Teratog Mutagen*, 5:9.

Mariani RL, Jorge MP, Pereira SS, Melione LP, Carvalho-Oliveira R, Ma TH et al. (2009). Association between micronuclei frequency in pollen mother cells of *Tradescantia* and mortality due to cancer and cardiovascular diseases: a preliminary study in Sao José dos Campos, Brazil. *Environ Pollut*, 157(6):1767–70. doi:10.1016/j.envpol.2009.02.023 PMID:19303678

Martin S, Dawidowski L, Mandalunis P, Cereceda-Balic F, Tasat DR (2007). Characterization and biological effect of Buenos Aires urban air particles on mice lungs. *Environ Res*, 105(3):340–9. doi:10.1016/j.envres.2007.04.009 PMID:17628521

Martin S, Fernandez-Alanis E, Delfosse V, Evelson P, Yakisich JS, Saldiva PH et al. (2010). Low doses of urban air particles from Buenos Aires promote oxidative stress and apoptosis in mice lungs. *Inhal Toxicol*, 22(13):1064–71. doi:10.3109/08958378.2010.523030 PMID:21047167

Massolo L, Müller A, Tueros M, Rehwagen M, Franck U, Ronco A et al. (2002). Assessment of mutagenicity and toxicity of different-size fractions of air particulates from La Plata, Argentina, and Leipzig, Germany. *Environ Toxicol*, 17(3):219–31. doi:10.1002/tox.10054 PMID:12112630

Matsumoto H, Inoue K (1987). Mutagenicity of a polar portion in the neutral fraction separated from organic

extracts of airborne particulates. *Arch Environ Contam Toxicol*, 16(4):409–16. doi:10.1007/BF01055261 PMID:3606201

Matsumoto M, Ando M, Tamura K (1993). Differences of mutagenic activity of airborne particulates by particle size – assay by the *Salmonella* microsuspension procedure. *Jpn J Toxicol Environ Health*, 39(2):139–47. doi:10.1248/jhs1956.39.2_139

Matsumoto Y, Sakai S, Kato T, Nakajima T, Satoh H (1998). Long-term trends of particulate mutagenic activity in atmosphere of Sapporo. 1. Determination of mutagenic activity by the conventional tester strains TA98 and TA100 during an 18-year period (1974–1992). *Environ Sci Technol*, 32(18):2665–71. doi:10.1021/es9801036

Matsushita H, Endo O, Goto S, Shimizu H, Matsumoto H, Tamakawa K et al. (1992). Collaborative study using the preincubation *Salmonella typhimurium* mutation assay for airborne particulate matter in Japan. A trial to minimize interlaboratory variation. *Mutat Res*, 271(1):1–12. doi:10.1016/0165-1161(92)90027-J PMID:1371825

Meireles J, Rocha R, Neto AC, Cerqueira E (2009). Genotoxic effects of vehicle traffic pollution as evaluated by micronuclei test in *Tradescantia* (Trad-MCN). *Mutat Res*, 675(1–2):46–50. doi:10.1016/j.mrgentox.2009.02.005 PMID:19386247

Melendez-Gelvez I, Martinez M, Quijano A (2012). Mutagenic and genotoxic activity of particulate matter $MP_{2,5}$ in Pamplona, North Santander, Colombia. *Iatreia*, 25(4):347–56.

Mendez R, Zheng Z, Fan Z, Rajagopalan S, Sun Q, Zhang K (2013). Exposure to fine airborne particulate matter induces macrophage infiltration, unfolded protein response, and lipid deposition in white adipose tissue. *Am J Transl Res*, 5(2):224–34. PMID:23573366

Miguel AG, Daisey JM, Sousa JA (1990). Comparative study of the mutagenic and genotoxic activity associated with inhalable particulate matter in Rio de Janeiro air. *Environ Mol Mutagen*, 15(1):36–43. doi:10.1002/em.2850150106 PMID:2137085

Misík M, Micieta K, Solenská M, Misíková K, Pisarcíková H, Knasmüller S (2007). In situ biomonitoring of the genotoxic effects of mixed industrial emissions using the *Tradescantia* micronucleus and pollen abortion tests with wild life plants: demonstration of the efficacy of emission controls in an eastern European city. *Environ Pollut*, 145(2):459–66. doi:10.1016/j.envpol.2006.04.026 PMID:16815607

Misík M, Solenská M, Micieta K, Misíková K, Knasmüller S (2006). In situ monitoring of clastogenicity of ambient air in Bratislava, Slovakia using the *Tradescantia* micronucleus assay and pollen abortion assays. *Mutat Res*, 605(1–2):1–6. doi:10.1016/j.mrgentox.2005.12.009 PMID:16702021

Mo ZY, Xiao BQ, Kwan JK, Yu ZD, Fang M (1998). Mutagenic analysis on organic extracts of aerosol samples in new city region of Kowloon H.K. *Carcinog Teratog Mutagen*, 10:218–23.

Møller M, Alfheim I (1980). Mutagenicity and PAH-analysis of airborne particulate matter. *Atmos Environ*, 14(1):83–8. doi:10.1016/0004-6981(80)90111-0 PMID:6986880

Møller M, Alfheim I, Larssen S, Mikalsen A (1982). Mutagenicity of airborne particles in relation to traffic and air pollution parameters. *Environ Sci Technol*, 16(4):221–5. doi:10.1021/es00098a010

Monarca S, Crebelli R, Feretti D, Zanardini A, Fuselli S, Filini L et al. (1997). Mutagens and carcinogens in size-classified air particulates of a northern Italian town. *Sci Total Environ*, 205(2–3):137–44. doi:10.1016/S0048-9697(97)00194-0 PMID:9372626

Monarca S, Feretti D, Zanardini A, Falistocco E, Nardi G (1999). Monitoring of mutagens in urban air samples. *Mutat Res*, 426(2):189–92. doi:10.1016/S0027-5107(99)00066-4 PMID:10350596

Monn C, Naef R, Koller T (2003). Reactions of macrophages exposed to particles <10 microm. *Environ Res*, 91(1):35–44. doi:10.1016/S0013-9351(02)00021-X PMID:12550086

Moreno T, Merolla L, Gibbons W, Greenwell L, Jones T, Richards R (2004). Variations in the source, metal content and bioreactivity of technogenic aerosols: a case study from Port Talbot, Wales, UK. *Sci Total Environ*, 333(1–3):59–73. doi:10.1016/j.scitotenv.2004.04.019 PMID:15364519

Moriske HJ, Block I, Schleibinger H, Rüden H (1985). Polar neutral organic compounds in urban aerosols. 1. Chemical characterization and mutagenic effect in relation to various sources [in German]. *Zentralbl Bakteriol Mikrobiol Hyg B*, 181(3–5):240–71. PMID:4096145

Moriske HJ, Rüden H (1988). Polar organic components in emission and immission samples from urban suspended particulates and their mutagenicity in the AMES-bioassay. *Chemosphere*, 17(6):1167–81. doi:10.1016/0045-6535(88)90183-X

Moriske HJ, Wullenweber M, Ketseridis G, Rüden H (1982). Mutagenic effect of polycyclic aromatic hydrocarbons (PAH) and polar organic compounds (POC) in urban aerosols [in German]. *Zentralbl Bakteriol Mikrobiol Hyg B*, 176(5–6):508–18. PMID:7158130

Morozzi G, Mastrandrea V, Trotta F, Tonti A, Scardazza F, Cenci E (1992). Chemical characterization and biological properties of airborne particulate matter. *Aerobiologia*, 8(3):451–7. doi:10.1007/BF02272915

Morris WA, Versteeg JK, Bryant DW, Legzdins AE, McCarry BE, Marvin CH (1995). Preliminary comparisons between mutagenicity and magnetic susceptibility of respirable airborne particulate. *Atmos Environ*, 29(23):3441–50. doi:10.1016/1352-2310(95)00203-B

Motykiewicz G, Cimander B, Szeliga J, Tkocz A, Chorazy M (1990). Mutagenic activity of complex air pollutants in Silesia. In: Vainio H, Sorsa M, McMichael AJ.

Complex mixtures and cancer risk *IARC Sci Publ*, 104:261–8. PMID:2228124

Motykiewicz G, Manka G, Cimander B, Chorazy M (1985). Mutagenic activity in air-borne particulate pollutants at industrial district of Silesia. *Bull Pol Acad Sci Biol Sci*, 33(1–6):7–16.

Motykiewicz G, Szeliga J, Cimander B, Choraży M (1989). Seasonal variations in mutagenic activity of air pollutants at an industrial district of Silesia. *Mutat Res*, 223(2):243–51. doi:10.1016/0165-1218(89)90052-9 PMID:2739681

Müller A, Alzuet P, Herbarth O, Ronco A (2001). Assessment of toxicity and mutagenicity in air particulate matter from an urban industrial area in the coast of the Rio de la Plata. *Environ Toxicol*, 16(2):151–7. doi:10.1002/tox.1019 PMID:11339715

Nardini B, Clonfero E (1992). Mutagens in urban air particulate. *Mutagenesis*, 7(6):421–5. doi:10.1093/mutage/7.6.421 PMID:1474917

Nawrot TS, Kuenzli N, Sunyer J, Shi T, Moreno T, Viana M et al. (2009). Oxidative properties of ambient $PM_{2.5}$ and elemental composition: heterogeneous associations in 19 European cities. *Atmos Environ*, 43(30):4595–602. doi:10.1016/j.atmosenv.2009.06.010

Nielsen PA (1992). Mutagenicity studies on complex environmental mixtures: selection of solvent system for extraction. *Mutat Res*, 276(1–2):117–23. doi:10.1016/0165-1110(92)90060-M PMID:1370102

Nielsen PS, de Pater N, Okkels H, Autrup H (1996b). Environmental air pollution and DNA adducts in Copenhagen bus drivers – effect of *GSTM1* and *NAT2* genotypes on adduct levels. *Carcinogenesis*, 17(5):1021–7. doi:10.1093/carcin/17.5.1021 PMID:8640907

Nielsen PS, Okkels H, Sigsgaard T, Kyrtopoulos S, Autrup H (1996a). Exposure to urban and rural air pollution: DNA and protein adducts and effect of glutathione-*S*-transferase genotype on adduct levels. *Int Arch Occup Environ Health*, 68(3):170–6. doi:10.1007/BF00381627 PMID:8919845

Nishioka MG, Chuang CC, Petersen BA, Austin A, Lewtas J (1985). Development and quantitative evaluation of a compound class fractionation scheme for bioassay-directed characterization of ambient air particulate matter. *Environ Int*, 11(2–4):137–46. doi:10.1016/0160-4120(85)90007-8

Novotna B, Topinka J, Solansky I, Chvatalova I, Lnenickova Z, Sram RJ (2007). Impact of air pollution and genotype variability on DNA damage in Prague policemen. *Toxicol Lett*, 172(1–2):37–47. doi:10.1016/j.toxlet.2007.05.013 PMID:17590289

Ntziachristos L, Froines JR, Cho AK, Sioutas C (2007). Relationship between redox activity and chemical speciation of size-fractionated particulate matter. *Part Fibre Toxicol*, 4(1):5 doi:10.1186/1743-8977-4-5 PMID:17555562

Nylund L, Hakala E, Sorsa M (1992). Application of a semi-automated SOS chromotest for measuring genotoxicities of complex environmental mixtures containing polycyclic aromatic hydrocarbons. *Mutat Res*, 276(1–2):125–32. doi:10.1016/0165-1110(92)90061-D PMID:1370103

Oda Y, Funasaka K, Kitano M, Nakama A, Yoshikura T (2004). Use of a high-throughput *umu*-microplate test system for rapid detection of genotoxicity produced by mutagenic carcinogens and airborne particulate matter. *Environ Mol Mutagen*, 43(1):10–9. doi:10.1002/em.10209 PMID:14743341

Oh SM, Kim HR, Park YJ, Lee SY, Chung KH (2011). Organic extracts of urban air pollution particulate matter ($PM_{2.5}$)-induced genotoxicity and oxidative stress in human lung bronchial epithelial cells (BEAS-2B cells). *Mutat Res*, 723(2):142–51. doi:10.1016/j.mrgentox.2011.04.003 PMID:21524716

Ohsawa M, Ochi T, Hayashi H (1983). Mutagenicity in *Salmonella typhimurium* mutants of serum extracts from airborne particulates. *Mutat Res*, 116(2):83–90. doi:10.1016/0165-1218(83)90099-X PMID:6338361

Ohtani Y, Shimada Y, Ujiiye A (1985). Comparison between mutagenic activities of airborne particulates in Maebashi and in Minato-ku Tokyo. *J Jpn Soc Air Pollut*, 20:463–9.

Ohyama M, Otake T, Adachi S, Kobayashi T, Morinaga K (2007). A comparison of the production of reactive oxygen species by suspended particulate matter and diesel exhaust particles with macrophages. *Inhal Toxicol*, 19:Suppl 1: 157–60. doi:10.1080/08958370701496103 PMID:17886063

Pagano P, De Zaiacomo T, Scarcella E, Bruni S, Calamosca M (1996). Mutagenic activity of total and particle-sized fractions of urban particulate matter. *Environ Sci Technol*, 30(12):3512–6. doi:10.1021/es960182q

Palli D, Russo A, Masala G, Saieva C, Guarrera S, Carturan S et al. (2001). DNA adduct levels and DNA repair polymorphisms in traffic-exposed workers and a general population sample. *Int J Cancer*, 94(1):121–7. doi:10.1002/ijc.1433 PMID:11668486

Papathomas M, Molitor J, Richardson S, Riboli E, Vineis P (2011). Examining the joint effect of multiple risk factors using exposure risk profiles: lung cancer in nonsmokers. *Environ Health Perspect*, 119(1):84–91. doi:10.1289/ehp.1002118 PMID:20920953

Pastorelli R, Restano J, Guanci M, Maramonte M, Magagnotti C, Allevi R et al. (1996). Hemoglobin adducts of benzo[*a*]pyrene diolepoxide in newspaper vendors: association with traffic exhaust. *Carcinogenesis*, 17(11):2389–94. doi:10.1093/carcin/17.11.2389 PMID:8968053

Pastorková A, Cerná M, Smíd J, Vrbíková V (2004). Mutagenicity of airborne particulate matter PM_{10}. *Cent Eur J Public Health*, 12:Suppl: S72–5. PMID:15141986

Pereira CE, Heck TG, Saldiva PH, Rhoden CR (2007). Ambient particulate air pollution from vehicles promotes lipid peroxidation and inflammatory responses in rat lung. *Braz J Med Biol Res*, 40(10):1353–9. doi:10.1590/S0100-879X2006005000164 PMID:17713644

Pereira TS, Beltrami LS, Rocha JAV, Broto FP, Comellas LR, Salvadori DM et al. (2013). Toxicogenetic monitoring in urban cities exposed to different airborne contaminants. *Ecotoxicol Environ Saf*, 90:174–82. doi:10.1016/j.ecoenv.2012.12.029 PMID:23395453

Pereira TS, Gotor GN, Beltrami LS, Nolla CG, Rocha JA, Broto FP et al. (2010). *Salmonella* mutagenicity assessment of airborne particulate matter collected from urban areas of Rio Grande do Sul State, Brazil, differing in anthropogenic influences and polycyclic aromatic hydrocarbon levels. *Mutat Res*, 702(1):78–85. doi:10.1016/j.mrgentox.2010.07.003 PMID:20643224

Piao FY, Duan ZW, Zhang YM, Cui JS, Sun XC, Yang G et al. (2007). Concentrations and mutagenic activity of polycyclic aromatic hydrocarbons. *Carcinog Teratog Mutagen*, 19:143–5.

Piekarska K (2009). Mutagenic effect of main groups of organic pollutants adsorbed on suspended particulate matter (PM_{10} and $PM_{2.5}$) collected within Wrocław urban area. *Environ Prot Eng*, 35(1):23–35.

Piekarska K (2010). Mutagenicity of airborne particulates assessed by *Salmonella* assay and the SOS chromotest in Wrocław, Poland. *J Air Waste Manag Assoc*, 60(8):993–1001. doi:10.3155/1047-3289.60.8.993 PMID:20842939

Piekarska K, Karpińska-Smulikowska J (2006). Effect of microsomal fraction induction on the detectability of mutagenic air pollutants by means of the Ames bacterial mutagenicity test *Environ Prot Eng*, 32(4):15–23.

Piekarska K, Karpińska-Smulikowska J (2007). Mutagenic activity of environmental air samples from the area of Wrocław, Poland. *Pol J Environ Stud*, 16(5):745–52.

Piekarska K, Zaciera M, Czarny A, Zaczyńska E (2009). Mutagenic and cytotoxic properties of extracts of suspended particulate matter collected in Wrocław city area. *Environ Prot Eng*, 35:37–48.

Piekarska K, Zaciera M, Czarny A, Zaczyńska E (2011). Application of short-term tests in assessment of atmospheric air pollution. *Environ Prot Eng*, 37(2):85–98.

Pintér A, Bejczi K, Csik M, Kelecsényi Z, Kertész M, Surján A et al. (1990). Mutagenicity of emission and immission samples around industrial areas. In: Vainio H, Sorsa M, McMichael AJ. Complex mixtures and cancer risk. *IARC Sci Publ*, 104:269–76. PMID:2228125

Piraino F, Aina R, Palin L, Prato N, Sgorbati S, Santagostino A et al. (2006). Air quality biomonitoring: assessment of air pollution genotoxicity in the Province of Novara (North Italy) by using *Trifolium repens* L. and molecular markers. *Sci Total Environ*, 372(1):350–9. doi:10.1016/j.scitotenv.2006.09.009 PMID:17055033

Pitts JN Jr, Grosjean D, Mischke TM, Simmon VF, Poole D (1977). Mutagenic activity of airborne particulate organic pollutants. *Toxicol Lett*, 1(2):65–70. doi:10.1016/0378-4274(77)90023-6

Pitts JN Jr, Sweetman JA Jr, Harger W, Fitz DR, Paur HR, Winer AM (1985). Diurnal mutagenicity of airborne particulate organic matter adjacent to a heavily traveled West Los Angeles freeway. *J Air Pollut Control Assoc*, 35(6):638–43. doi:10.1080/00022470.1985.10465939 PMID:2410469

Poli P, Buschini A, Campanini N, Vettori MV, Cassoni F, Cattani S et al. (1992). Urban air pollution: use of different mutagenicity assays to evaluate environmental genetic hazard. *Mutat Res*, 298(2):113–23. doi:10.1016/0165-1218(92)90036-Y PMID:1282207

Poli P, Buschini A, Restivo FM, Ficarelli A, Cassoni F, Ferrero I et al. (1999). Comet assay application in environmental monitoring: DNA damage in human leukocytes and plant cells in comparison with bacterial and yeast tests. *Mutagenesis*, 14(6):547–56. doi:10.1093/mutage/14.6.547 PMID:10567029

Poma A, Arrizza L, Picozzi P, Spanò L (2002). Monitoring urban air particulate matter (fractions $PM_{2.5}$ and PM_{10}) genotoxicity by plant systems and human cells in vitro: a comparative analysis. *Teratog Carcinog Mutagen*, 22(4):271–84. doi:10.1002/tcm.10020 PMID:12111711

Prahalad AK, Inmon J, Dailey LA, Madden MC, Ghio AJ, Gallagher JE (2001). Air pollution particles mediated oxidative DNA base damage in a cell free system and in human airway epithelial cells in relation to particulate metal content and bioreactivity. *Chem Res Toxicol*, 14(7):879–87. doi:10.1021/tx010022e PMID:11453735

Prahalad AK, Inmon J, Ghio AJ, Gallagher JE (2000). Enhancement of 2′-deoxyguanosine hydroxylation and DNA damage by coal and oil fly ash in relation to particulate metal content and availability. *Chem Res Toxicol*, 13(10):1011–9. doi:10.1021/tx000110j PMID:11080050

Prajapati SK, Tripathi BD (2008). Assessing the genotoxicity of urban air pollutants in Varanasi City using *Tradescantia* micronucleus (Trad-MCN) bioassay. *Environ Int*, 34(8):1092–6. doi:10.1016/j.envint.2008.03.009 PMID:18455797

Prasad SB, Vidyullatha P, Vani GT, Devi RP, Rani UP, Reddy PP et al. (2013). Association of gene polymorphism in detoxification enzymes and urinary 8-OHdG levels in traffic policemen exposed to vehicular exhaust. *Inhal Toxicol*, 25(1):1–8. PMID:23293967

Preidecker BL (1980a). II. Comparative extraction of Houston air particulates with cyclohexane or a mixture of benzene, methanol, and dichloromethane. *Environ Mutagen*, 2(1):85–8. doi:10.1002/em.2860020112 PMID:7035160

Preidecker BL (1980b). I. Bacterial mutagenicity of particulates from Houston air. *Environ Mutagen*, 2(1):75–83. doi:10.1002/em.2860020111 PMID:7035159

Pyysalo H, Tuominen J, Wickstrom K, Skyttä E, Tikkanen L, Salomaa S et al. (1987). Polycyclic organic material (POM) in urban air. Fractionation, chemical analysis

and genotoxicity of particulate and vapour phases in an industrial town in Finland. *Atmos Environ*, 21(5):1167–80. doi:10.1016/0004-6981(87)90244-7

Qian LM, Wang WX, Wang WT (1996). Effects of meteorological conditions on SOS-inducing potency of airborne particulates in Guangzhou. *J Guangzhou Normal Univ*, 2:59–64.

Qian LM, Zhang BQ (1997). Breakpoint regression in research of airborne particulate genotoxicity. *J Biomath*, 12:93–6.

Qian LM, Zhang BQ, Wang WX (1997). Correlation between genotoxicity of airborne particulates and meteorological condition in Guangzhou city. *Chin J Publ Health*, 16:160–2.

Qu S, Liberda EN, Qu Q, Chen LC (2010). In vitro assessment of the inflammatory response of respiratory endothelial cells exposed to particulate matter. *J Toxicol Environ Health A*, 73(16):1113–21. doi:10.1080/15287394.2010.484335 PMID:20574913

Quintana R, Serrano J, Gómez V, de Foy B, Miranda J, Garcia-Cuellar C et al. (2011). The oxidative potential and biological effects induced by PM_{10} obtained in Mexico City and at a receptor site during the MILAGRO Campaign. *Environ Pollut*, 159(12):3446–54. doi:10.1016/j.envpol.2011.08.022 PMID:21899937

Reali D, Schlitt H, Lohse C, Barale R, Loprieno N (1984). Mutagenicity and chemical analysis of airborne particulates from a rural area in Italy. *Environ Mutagen*, 6(6):813–23. doi:10.1002/em.2860060608 PMID:6389109

Reche C, Moreno T, Amato F, Viana M, van Drooge BL, Chuang HC et al. (2012). A multidisciplinary approach to characterise exposure risk and toxicological effects of PM_{10} and $PM_{2.5}$ samples in urban environments. *Ecotoxicol Environ Saf*, 78:327–35. doi:10.1016/j.ecoenv.2011.11.043 PMID:22177483

Rhoden CR, Lawrence J, Godleski JJ, González-Flecha B (2004). N-acetylcysteine prevents lung inflammation after short-term inhalation exposure to concentrated ambient particles. *Toxicol Sci*, 79(2):296–303. doi:10.1093/toxsci/kfh122 PMID:15056806

Richter E, Rösler S, Scherer G, Gostomzyk JG, Grübl A, Krämer U et al. (2001). Haemoglobin adducts from aromatic amines in children in relation to area of residence and exposure to environmental tobacco smoke. *Int Arch Occup Environ Health*, 74(6):421–8. doi:10.1007/s004200100243 PMID:11563605

Riva DR, Magalhães CB, Lopes AA, Lanças T, Mauad T, Malm O et al. (2011). Low dose of fine particulate matter ($PM_{2.5}$) can induce acute oxidative stress, inflammation and pulmonary impairment in healthy mice. *Inhal Toxicol*, 23(5):257–67. doi:10.3109/08958378.2011.566290 PMID:21506876

Roberts ES, Richards JH, Jaskot R, Dreher KL (2003). Oxidative stress mediates air pollution particle-induced acute lung injury and molecular pathology. *Inhal Toxicol*, 15(13):1327–46. doi:10.1080/08958370390241795 PMID:14569496

Rogstad SH, Keane B, Collier MH (2003). Minisatellite DNA mutation rate in dandelions increases with leaf-tissue concentrations of Cr, Fe, Mn, and Ni. *Environ Toxicol Chem*, 22(9):2093–9. doi:10.1002/etc.5620220919 PMID:12959536

Rossi C, Poli P, Buschini A, Cassoni F, Cattani S, DeMunari E (1995). Comparative investigations among meteorological conditions, air chemical-physical pollutants and airborne particulate mutagenicity: a long-term study (1990–1994) from a northern Italian town. *Chemosphere*, 30(10):1829–45. doi:10.1016/0045-6535(95)00065-G PMID:7780721

Rossner P Jr, Topinka J, Hovorka J, Milcova A, Schmuczerova J, Krouzek J et al. (2010). An acellular assay to assess the genotoxicity of complex mixtures of organic pollutants bound on size segregated aerosol. Part II: oxidative damage to DNA. *Toxicol Lett*, 198(3):312–6. doi:10.1016/j.toxlet.2010.06.021 PMID:20603203

Rowan-Carroll A, Halappanavar S, Williams A, Somers CM, Yauk CL (2013). Mice exposed in situ to urban air pollution exhibit pulmonary alterations in gene expression in the lipid droplet synthesis pathways. *Environ Mol Mutagen*, 54(4):240–9. doi:10.1002/em.21768 PMID:23536514

Rubes J, Rybar R, Prinosilova P, Veznik Z, Chvatalova I, Solansky I et al. (2010). Genetic polymorphisms influence the susceptibility of men to sperm DNA damage associated with exposure to air pollution. *Mutat Res*, 683(1–2):9–15. doi:10.1016/j.mrfmmm.2009.09.010 PMID:19800896

Ruchirawat M, Mahidol C, Tangjarukij C, Pui-ock S, Jensen O, Kampeerawipakorn O et al. (2002). Exposure to genotoxins present in ambient air in Bangkok, Thailand – particle associated polycyclic aromatic hydrocarbons and biomarkers. *Sci Total Environ*, 287(1–2):121–32. doi:10.1016/S0048-9697(01)01008-7 PMID:11883753

Ruchirawat M, Settachan D, Navasumrit P, Tuntawiroon J, Autrup H (2007). Assessment of potential cancer risk in children exposed to urban air pollution in Bangkok, Thailand. *Toxicol Lett*, 168(3):200–9. doi:10.1016/j.toxlet.2006.09.013 PMID:17157453

Sadowska A, Pluygers E, Narkiewicz M, Pawelczak A, Lata B (1994). Environmental genotoxicity and cancer risk in humans: a combined evaluation correlating the results of the *Tradescantia* micronucleus assay in the field and human biomarker assessments in serum. I. The TRAD-MCN assay. *Eur J Cancer Prev*, 3(1):69–78. doi:10.1097/00008469-199401000-00010 PMID:8130720

Sadowska A, Pluygers E, Niklińska W, Maria MR, Obidoska G (2001). Use of higher plants in the biomonitoring of

environmental genotoxic pollution. *Folia Histochem Cytobiol*, 39:Suppl 2: 52–3. PMID:11820626

Sadowska A, van Larebeke N, Amaral Mendes JG, Husson B, Wagner Z, Pluygers E (1999). Exposure to pollutants: genotoxic effects in plants and immunotoxic effects in humans. *J Agric Saf Health*, 5(1):109–30. doi:10.13031/2013.5674

Saint-Georges F, Abbas I, Billet S, Verdin A, Gosset P, Mulliez P et al. (2008). Gene expression induction of volatile organic compound and/or polycyclic aromatic hydrocarbon-metabolizing enzymes in isolated human alveolar macrophages in response to airborne particulate matter ($PM_{2.5}$). *Toxicology*, 244(2–3):220–30. doi:10.1016/j.tox.2007.11.016 PMID:18178302

Sakitani T, Hayashi K (1986). Mutagenic activities of air pollutants. Part 1. Diurnal and seasonal variations in the concentrations of six polycyclic aromatic hydrocarbons in the urban air and the relationship between their concentrations and mutagenic activities. *Tokyo Jikeikai Med J*, 101:247–57.

Sakitani T, Suzuki Y (1986). Mutagenic activities of air pollutants. Part 2. Mutagenic activities of air pollutants observed by micronucleus test. *Tokyo Jikeikai Med J*, 101:259–66.

Salamone MF, Heddle JA, Katz M (1979). The mutagenic activity of thirty polycyclic aromatic hydrocarbons (PAH) and oxides in urban airborne particulates. *Environ Int*, 2(1):37–43. doi:10.1016/0160-4120(79)90092-8

Saldiva PH, Clarke RW, Coull BA, Stearns RC, Lawrence J, Murthy GG et al. (2002). Lung inflammation induced by concentrated ambient air particles is related to particle composition. *Am J Respir Crit Care Med*, 165(12):1610–7. doi:10.1164/rccm.2106102 PMID:12070061

Salonen RO, Hälinen AI, Pennanen AS, Hirvonen MR, Sillanpää M, Hillamo R et al. (2004). Chemical and in vitro toxicologic characterization of wintertime and springtime urban-air particles with an aerodynamic diameter below 10 microm in Helsinki. *Scand J Work Environ Health*, 30:Suppl 2: 80–90. PMID:15487689

Sasaki Y, Kawai T, Ohyama K, Nakama A, Endo R (1987). Carcinogenicity of extract of airborne particles using newborn mice and comparative study of carcinogenic and mutagenic effect of the extract. *Arch Environ Health*, 42(1):14–8. doi:10.1080/00039896.1987.9935789 PMID:3566345

Sato MIZ, Valent GU, Coimbrão CA, Coelho MC, Sanchez Sanchez P, Alonso CD et al. (1995). Mutagenicity of airborne particulate organic material from urban and industrial areas of São Paulo, Brazil. *Mutat Res*, 335(3):317–30. doi:10.1016/0165-1161(95)00035-6 PMID:8524347

Savard S, Otson R, Douglas GR (1992). Mutagenicity and chemical analysis of sequential organic extracts of airborne particulates. *Mutat Res*, 276(1–2):101–15. doi:10.1016/0165-1110(92)90059-I PMID:1370100

Savóia EJ, Domingos M, Guimarães ET, Brumati F, Saldiva PH (2009). Biomonitoring genotoxic risks under the urban weather conditions and polluted atmosphere in Santo André, SP, Brazil, through Trad-MCN bioassay. *Ecotoxicol Environ Saf*, 72(1):255–60. doi:10.1016/j.ecoenv.2008.03.019 PMID:18571723

Sawyer K, Mundandhara S, Ghio AJ, Madden MC (2010). The effects of ambient particulate matter on human alveolar macrophage oxidative and inflammatory responses. *J Toxicol Environ Health A*, 73(1):41–57. doi:10.1080/15287390903248901 PMID:19953419

Scarpato R, Di Marino F, Strano A, Curti A, Campagna R, Loprieno N et al. (1993). Two years' air mutagenesis monitoring in a northwestern rural area of Italy with an industrial plant. *Mutat Res*, 319(4):293–301. doi:10.1016/0165-1218(93)90018-9 PMID:7504203

Schairer LA, Sautkulis RC, Tempel NR (1982). Monitoring ambient air for mutagenicity using the higher plant Tradescantia. In: Tice RR, Costa DL, Schaich KM, editors. Genotoxic effects of airborne agents. New York (NY): Springer; pp. 123–40. Available from: http://dx.doi.org/10.1007/978-1-4613-3455-2_11.

Schaumann F, Borm PJ, Herbrich A, Knoch J, Pitz M, Schins RP et al. (2004). Metal-rich ambient particles (particulate $matter_{2.5}$) cause airway inflammation in healthy subjects. *Am J Respir Crit Care Med*, 170(8):898–903. doi:10.1164/rccm.200403-423OC PMID:15229099

Scherer G, Frank S, Riedel K, Meger-Kossien I, Renner T (2000). Biomonitoring of exposure to polycyclic aromatic hydrocarbons of nonoccupationally exposed persons. *Cancer Epidemiol Biomarkers Prev*, 9(4):373–80. PMID:10794481

Schins RP, Lightbody JH, Borm PJ, Shi T, Donaldson K, Stone V (2004). Inflammatory effects of coarse and fine particulate matter in relation to chemical and biological constituents. *Toxicol Appl Pharmacol*, 195(1):1–11. doi:10.1016/j.taap.2003.10.002 PMID:14962500

Schneider JC, Card GL, Pfau JC, Holian A (2005). Air pollution particulate SRM 1648 causes oxidative stress in RAW 264.7 macrophages leading to production of prostaglandin E2, a potential Th2 mediator. *Inhal Toxicol*, 17(14):871–7. doi:10.1080/08958370500244498 PMID:16282164

Seemayer NH, Hadnagy W, Tomingas R (1987a). Mutagenic and carcinogenic effects of airborne particulate matter from polluted areas on human and rodent tissue cultures. *Experientia Suppl*, 51:231–4. doi:10.1007/978-3-0348-7491-5_39 PMID:2958327

Seemayer NH, Hadnagy W, Tomingas R (1990a). Enhancement of cell transformation and induction of sister chromatid exchanges as test systems for detection of seasonal and local differences in genotoxicity of airborne particulates. In: Seemayer NH, Hadnagy W, editors. Environmental hygiene II. Berlin, Germany: Springer-Verlag; pp. 50–3. Available from: http://dx.doi.org/10.1007/978-3-642-46712-7_12.

Seemayer NH, Hadnagy W, Tomingas R, Manojlovic N (1987b). Cell- and genotoxic activities of airborne particulates from a highly industrialized region: a survey over a period of 11 years (1975–1986). *J Aerosp Sci*, 18(6):721–4. doi:10.1016/0021-8502(87)90106-6

Seemayer NH, Hornberg C (1998). Malignant transformation of Syrian hamster kidney cells in vitro by interaction of airborne particulates and simian virus (SV-) 40. *Toxicol Lett*, 96–97(1–2):231–8. doi:10.1016/S0378-4274(98)00077-0 PMID:9820672

Seemayer NH, Manojlovic N, Konig H, Tomingas R (1988). Comparative investigation of carcinogenic and mutagenic activity of airborne particulate matter from polluted areas using human and rodent tissue culture cells. *Ann Occup Hyg*, 32:(6): 247–56. doi:10.1093/annhyg/32.inhaled_particles_VI.247

Seemayer NH, Manojlovic N, Schurer CC, Tomingas R (1984). Cell cultures as a tool for detection of cytotoxic, mutagenic and carcinogenic activity of airborne particulate matter. *J Aerosol Sci*, 15(3):426–30. doi:10.1016/0021-8502(84)90135-6

Seemayer NH, Manojlovic N, Tomingas R (1981). Cell transformation in vitro by city smog extracts and fractions. *Mutat Res*, 85(6):453–4. doi:10.1016/0165-1161(81)90271-5

Senlin L, Zhenkun Y, Xiaohui C, Minghong W, Guoying S, Jiamo F et al. (2008). The relationship between physicochemical characterization and the potential toxicity of fine particulates ($PM_{2.5}$) in Shanghai atmosphere. *Atmos Environ*, 42(31):7205–14. doi:10.1016/j.atmosenv.2008.07.030

Sera N, Fukuhara K, Miyata N, Tokiwa H (1994). Detection of nitro-azabenzo[*a*]pyrene derivatives in the semivolatile phase originating from airborne particulate matter, diesel and gasoline vehicles. *Mutagenesis*, 9(1):47–52. doi:10.1093/mutage/9.1.47 PMID:8208130

Sevastyanova O, Binkova B, Topinka J, Sram RJ, Kalina I, Popov T et al. (2007). In vitro genotoxicity of PAH mixtures and organic extract from urban air particles part II: human cell lines. *Mutat Res*, 620(1-2):123–34. doi:10.1016/j.mrfmmm.2007.03.002 PMID:17420030

Shang Y, Fan L, Feng J, Lv S, Wu M, Li B et al. (2013). Genotoxic and inflammatory effects of organic extracts from traffic-related particulate matter in human lung epithelial A549 cells: the role of quinones. *Toxicol In Vitro*, 27(2):922–31. doi:10.1016/j.tiv.2013.01.008 PMID:23333790

Shao L, Shi Z, Jones TP, Li J, Whittaker AG, Bérubé KA (2006). Bioreactivity of particulate matter in Beijing air: results from plasmid DNA assay. *Sci Total Environ*, 367(1):261–72. doi:10.1016/j.scitotenv.2005.10.009 PMID:16313948

Sharma AK, Jensen KA, Rank J, White PA, Lundstedt S, Gagne R et al. (2007). Genotoxicity, inflammation and physico-chemical properties of fine particle samples from an incineration energy plant and urban air. *Mutat Res*, 633(2):95–111. doi:10.1016/j.mrgentox.2007.05.013 PMID:17683978

Shen H, Anastasio C (2011). Formation of hydroxyl radical from San Joaquin Valley particles extracted in a cell-free surrogate lung fluid. *Atmos Chem Phys*, 11(18):9671–82. doi:10.5194/acp-11-9671-2011 PMID:22121357

Shen H, Anastasio C (2012). A comparison of hydroxyl radical and hydrogen peroxide generation in ambient particle extracts and laboratory metal solutions. *Atmos Environ (1994)*, 46:665–8. doi:10.1016/j.atmosenv.2011.10.006 PMID:22267949

Shen H, Barakat AI, Anastasio C (2011). Generation of hydrogen peroxide from San Joaquin Valley particles in a cell-free solution. *Atmos Chem Phys*, 11(2):753–65. doi:10.5194/acp-11-753-2011

Shen RR, Sha LY, Wang ZS, Deng YH, Yang SS (2009). A toxicological study based on DNA damage of inhalable particulates collected in Macao during winter. *China Environ Sci*, 29:991–6.

Shenoy CN, Chaubal KA (1984). Study of mutagenic pollution in Bombay. *Sci Total Environ*, 38:275–81. doi:10.1016/0048-9697(84)90221-3 PMID:6523122

Shi T, Duffin R, Borm PJ, Li H, Weishaupt C, Schins RP (2006). Hydroxyl-radical-dependent DNA damage by ambient particulate matter from contrasting sampling locations. *Environ Res*, 101(1):18–24. doi:10.1016/j.envres.2005.09.005 PMID:16298360

Shi T, Knaapen AM, Begerow J, Birmili W, Borm PJ, Schins RP (2003). Temporal variation of hydroxyl radical generation and 8-hydroxy-2′-deoxyguanosine formation by coarse and fine particulate matter. *Occup Environ Med*, 60(5):315–21. doi:10.1136/oem.60.5.315 PMID:12709515

Shi ZB, Shao LY, Jones TP (2004). Oxidative DNA damage of urban airborne particulates in plasmid DNA assay. *Chin Sci Bull*, 49:673–8.

Shimizu H, Suzuki Y, Hayashi K (1982). Mutagenic activities of urban air pollutants: (part 1) diurnal and seasonal variations of mutagenicity of nitromethane extracts. *Tokyo Jikeikai Med J*, 97:785–95.

Shimizu H, Suzuki Y, Hayashi K (1983). Mutagenic activities of urban air pollutants: (part 2) diurnal and seasonal variations in mutagenicity of methanol extracts. *Tokyo Jikeikai Med J*, 98(5):711–9.

Shukla A, Timblin C, BeruBe K, Gordon T, McKinney W, Driscoll K et al. (2000). Inhaled particulate matter causes expression of nuclear factor (NF)-kappaB-related genes and oxidant-dependent NF-kappaB activation in vitro. *Am J Respir Cell Mol Biol*, 23(2):182–7. doi:10.1165/ajrcmb.23.2.4035 PMID:10919984

Sideropoulos AS, Specht S (1994). Mutagenicity of airborne particulates in Allegheny County: unmasking of potential carcinogenicity by size class fractionation. *Microbios*, 77(312):167–79. PMID:8170406

Sigaud S, Goldsmith CA, Zhou H, Yang Z, Fedulov A, Imrich A et al. (2007). Air pollution particles diminish

bacterial clearance in the primed lungs of mice. *Toxicol Appl Pharmacol*, 223(1):1–9. doi:10.1016/j.taap.2007.04.014 PMID:17561223

Singla V, Pachauri T, Satsangi A, Kumari KM, Lakhani A (2012). Characterization and mutagenicity assessment of $PM_{2.5}$ and PM_{10} PAH at Agra, India. *Polycycl Aromat Compd*, 32(2):199–220. doi:10.1080/10406638.2012.657740

Sisenando HA, de Medeiros SR, Saldiva PH, Artaxo P, Hacon SS (2011). Genotoxic potential generated by biomass burning in the Brazilian Legal Amazon by *Tradescantia* micronucleus bioassay: a toxicity assessment study. *Environ Health*, 10(1):41. doi:10.1186/1476-069X-10-41 PMID:21575274

Škarek M, Cupr P, Bartos T, Kohoutek J, Klánová J, Holoubek I (2007a). A combined approach to the evaluation of organic air pollution – a case study of urban air in Sarajevo and Tuzla (Bosnia and Herzegovina). *Sci Total Environ*, 384(1–3):182–93. doi:10.1016/j.scitotenv.2007.06.040 PMID:17675217

Škarek M, Janosek J, Cupr P, Kohoutek J, Novotná-Rychetská A, Holoubek I (2007b). Evaluation of genotoxic and non-genotoxic effects of organic air pollution using in vitro bioassays. *Environ Int*, 33(7):859–66. doi:10.1016/j.envint.2007.04.001 PMID:17512055

Smith KR, Aust AE (1997). Mobilization of iron from urban particulates leads to generation of reactive oxygen species in vitro and induction of ferritin synthesis in human lung epithelial cells. *Chem Res Toxicol*, 10(7):828–34. doi:10.1021/tx960164m PMID:9250418

Soberanes S, Gonzalez A, Urich D, Chiarella SE, Radigan KA, Osornio-Vargas A et al. (2012). Particulate matter air pollution induces hypermethylation of the p16 promoter via a mitochondrial ROS-JNK-DNMT1 pathway. *Sci Rep*, 2:275. doi:10.1038/srep00275 PMID:22355787

Solenská M, Micieta K, Misík M (2006). Plant bioassays for an in situ monitoring of air near an industrial area and a municipal solid waste: Zilina (Slovakia). *Environ Monit Assess*, 115(1–3):499–508. doi:10.1007/s10661-006-7240-2 PMID:16617421

Somers CM, McCarry BE, Malek F, Quinn JS (2004). Reduction of particulate air pollution lowers the risk of heritable mutations in mice. *Science*, 304(5673):1008–10. doi:10.1126/science.1095815 PMID:15143280

Somers CM, Yauk CL, White PA, Parfett CL, Quinn JS (2002). Air pollution induces heritable DNA mutations. *Proc Natl Acad Sci U S A*, 99(25):15904–7. doi:10.1073/pnas.252499499 PMID:12473746

Sorenson WG, Whong WZ, Simpson JP, Hearl FJ, Ong TM (1982). Studies of the mutagenic response of *Salmonella typhimurium* TA98 to size-fractionated air particles: comparison of the fluctuation and plate incorporation tests. *Environ Mutagen*, 4(5):531–41. doi:10.1002/em.2860040504 PMID:6754357

Soukup JM, Ghio AJ, Becker S, Joleen M (2000). Soluble components of Utah Valley particulate pollution alter alveolar macrophage function in vivo and in vitro. *Inhal Toxicol*, 12(5):401–14. doi:10.1080/089583700196112 PMID:10880136

Steenhof M, Gosens I, Strak M, Godri KJ, Hoek G, Cassee FR et al. (2011). In vitro toxicity of particulate matter (PM) collected at different sites in the Netherlands is associated with PM composition, size fraction and oxidative potential – the RAPTES project. *Part Fibre Toxicol*, 8(1):26. doi:10.1186/1743-8977-8-26 PMID:21888644

Stevens RK, Lewis CW, Dzubay TG, Cupitt LT, Lewtas J (1990). Sources of mutagenic activity in urban fine particles. *Toxicol Ind Health*, 6(5):81–94. PMID:2274994

Strandell M, Zakrisson S, Alsberg T, Westerholm R, Winquist L, Rannug U (1994). Chemical analysis and biological testing of a polar fraction of ambient air, diesel engine, and gasoline engine particulate extracts. *Environ Health Perspect*, 102:Suppl 4: 85–92. doi:10.1289/ehp.94102s485 PMID:7529708

Sutou S, Uemura I, Tomomatsu K, Yamamoto K, Ichihara A, Nakabori H et al. (1980). Mutagenicity of particulate air pollutants collected around Tokyo, Japan. *Bull Environ Contam Toxicol*, 24(2):225–30. doi:10.1007/BF01608101 PMID:6988024

Tablin F, den Hartigh LJ, Aung HH, Lame MW, Kleeman MJ, Ham W et al. (2012). Seasonal influences on CAPs exposures: differential responses in platelet activation, serum cytokines and xenobiotic gene expression. *Inhal Toxicol*, 24(8):506–17. doi:10.3109/08958378.2012.695815 PMID:22746400

Takagi Y, Sakiya K, Endoh O, Goto S, Kohzaki K, Murata M et al. (1992). Mutagenicity of airborne particulates in Sagamihara City. *J Vet Med Sci*, 54(2):193–9. doi:10.1292/jvms.54.193 PMID:1606249

Takeda N, Teranishi K (1986). Effects of environmental conditions on polycyclic aromatic hydrocarbons and mutagenicity of airborne particulate matter. *Bull Environ Contam Toxicol*, 36(5):685–92. PMID:3708171

Takeda N, Teranishi K, Hamada K (1983). Mutagenicity in *Salmonella typhimurium* TA98 of the serum extract of the organic matter derived from airborne particulates. *Mutat Res*, 117(1–2):41–6. doi:10.1016/0165-1218(83)90151-9 PMID:6339909

Takeda N, Teranishi K, Hamada K (1984). Mutagenicity of air pollutants collected at industrial, urban-residential and rural areas. *Bull Environ Contam Toxicol*, 32(6):688–92. doi:10.1007/BF01607557 PMID:6743859

Talcott R, Harger W (1980). Airborne mutagens extracted from particles of respirable size. *Mutat Res*, 79(2):177–80. doi:10.1016/0165-1218(80)90087-7 PMID:7001227

Talcott R, Wei E (1977). Airborne mutagens bioassayed in *Salmonella typhimurium*. *J Natl Cancer Inst*, 58(2):449–51. PMID:319246

Talcott RE, Harger W (1981). Chemical characterization of direct-acting airborne mutagens: the functional group. *Mutat Res*, 91(6):433–6. doi:10.1016/0165-7992(81)90048-8 PMID:7027034

Tan HH, Fiel MI, Sun Q, Guo J, Gordon RE, Chen LC et al. (2009). Kupffer cell activation by ambient air particulate matter exposure may exacerbate non-alcoholic fatty liver disease. *J Immunotoxicol*, 6(4):266–75. doi:10.3109/15476910903241704 PMID:19908945

Tao F, Kobzik L (2002). Lung macrophage-epithelial cell interactions amplify particle-mediated cytokine release. *Am J Respir Cell Mol Biol*, 26(4):499–505. doi:10.1165/ajrcmb.26.4.4749 PMID:11919087

Tarantini A, Maitre A, Lefebvre E, Marques M, Marie C, Ravanat JL et al. (2009). Relative contribution of DNA strand breaks and DNA adducts to the genotoxicity of benzo[*a*]pyrene as a pure compound and in complex mixtures. *Mutat Res*, 671(1–2):67–75. doi:10.1016/j.mrfmmm.2009.08.014 PMID:19733579

Teranishi K, Hamada K, Takeda N, Watanabe H (1978). Mutagenicity of the tar derived from air-borne particulate matters. *Mutat Res*, 54(2):229–30. doi:10.1016/0165-1161(78)90077-8 PMID:651938

Tian QX, Wu RM, Zhang BX (1985). A study on changing pattern of mutagens in airborne particulates in the city of Lanzhou. *Acta Scientiae Circumstantiae*, 5:201–11.

Tian QX, Zhou LZ, Wu RM (1992). The time space changing regularity of organic substances in airborne particulates at different height in Lanzhou city. *Acta Scientiae Circumstantiae*, 12:480–8.

Tokiwa H, Horikawa K, Sera N (1992). Influence of the microsomal inducer and the incubation system on mutagenicity of complex mixtures. *Mutat Res*, 276(1–2):139–44. doi:10.1016/0165-1110(92)90063-F PMID:1370105

Tokiwa H, Kitamori S, Nakagawa R, Horikawa K, Matamala L (1983). Demonstration of a powerful mutagenic dinitropyrene in airborne particulate matter. *Mutat Res*, 121(2):107–16. doi:10.1016/0165-7992(83)90108-2 PMID:6348530

Tokiwa H, Kitamori S, Takahashi K, Ohnishi Y (1980). Mutagenic and chemical assay of extracts of airborne particulates. *Mutat Res*, 77(2):99–108. doi:10.1016/0165-1218(80)90126-3 PMID:6990246

Tokiwa H, Morita K, Takeyoshi H, Takahashi K, Ohnishi Y (1977). Detection of mutagenic activity in particulate air pollutants. *Mutat Res*, 48(2):237–48. doi:10.1016/0027-5107(77)90165-8 PMID:327308

Topinka J, Rossner P Jr, Milcova A, Schmuczerova J, Svecova V, Sram RJ (2011). DNA adducts and oxidative DNA damage induced by organic extracts from $PM_{2.5}$ in an acellular assay. *Toxicol Lett*, 202(3):186–92. doi:10.1016/j.toxlet.2011.02.005 PMID:21329747

Topinka J, Schwarz LR, Wiebel FJ, Cerná M, Wolff T (2000). Genotoxicity of urban air pollutants in the Czech Republic. Part II. DNA adduct formation in mammalian cells by extractable organic matter. *Mutat Res*, 469(1):83–93. doi:10.1016/S1383-5718(00)00061-9 PMID:10946245

Török G, Csik M, Kertesz M, Fay E, Somorjay T, Börzsönyi M et al. (1989). Mutagenicity and PAH content of airborn particulates and of fallen dusts from two Hungarian towns and emission samples from aluminum reduction and power plants. *Ann Ist Super Sanita*, 25(4):595–9. PMID:2631626

Traversi D, Degan R, De Marco R, Gilli G, Pignata C, Ponzio M et al. (2008). Mutagenic properties of $PM_{2.5}$ air pollution in the Padana Plain (Italy) before and in the course of XX Winter Olympic Games of "Torino 2006". *Environ Int*, 34(7):966–70. doi:10.1016/j.envint.2008.02.007 PMID:18410966

Traversi D, Degan R, De Marco R, Gilli G, Pignata C, Villani S et al. (2009). Mutagenic properties of $PM_{2.5}$ urban pollution in the northern Italy: the nitro-compounds contribution. *Environ Int*, 35(6):905–10. doi:10.1016/j.envint.2009.03.010 PMID:19406477

Traversi D, Schilirò T, Degan R, Pignata C, Alessandria L, Gilli G (2011). Involvement of nitro-compounds in the mutagenicity of urban $PM_{2.5}$ and PM_{10} in Turin. *Mutat Res*, 726(1):54–9. doi:10.1016/j.mrgentox.2011.09.002 PMID:21920459

Tsai JH, Peng B-H, Lee D-Z, Lee C-C (1995). PAH characteristics and genotoxicity in the ambient air of a petrochemical industry complex. *Environ Int*, 21(1):47–56. doi:10.1016/0160-4120(94)00037-8

Tuominen J, Salomaa S, Pyysalo H, Skytta E, Tikkanen L, Nurmela T et al. (1988). Polynuclear aromatic compounds and genotoxicity in particulate and vapor phases of ambient air: effect of traffic, season, and meteorological conditions. *Environ Sci Technol*, 22(10):1228–34. doi:10.1021/es00175a017 PMID:22148620

Ulrich MM, Alink GM, Kumarathasan P, Vincent R, Boere AJ, Cassee FR (2002). Health effects and time course of particulate matter on the cardiopulmonary system in rats with lung inflammation. *J Toxicol Environ Health A*, 65(20):1571–95. doi:10.1080/00984100290071676 PMID:12396869

Umbuzeiro GA, Franco A, Martins MH, Kummrow F, Carvalho L, Schmeiser HH et al. (2008). Mutagenicity and DNA adduct formation of PAH, nitro-PAH, and oxy-PAH fractions of atmospheric particulate matter from São Paulo, Brazil. *Mutat Res*, 652(1):72–80. doi:10.1016/j.mrgentox.2007.12.007 PMID:18294902

Umbuzeiro GdeA, Rech CM, Correia S, Bergamasco AM, Cardenette GH, Flückiger-Isler S et al. (2010). Comparison of the *Salmonella*/microsome microsuspension assay with the new microplate fluctuation protocol for testing the mutagenicity of environmental samples. *Environ Mol Mutagen*, 51(1):31–8. PMID:19484728

Valavanidis A, Fiotakis K, Bakeas E, Vlahogianni T (2005). Electron paramagnetic resonance study of the

generation of reactive oxygen species catalysed by transition metals and quinoid redox cycling by inhalable ambient particulate matter. *Redox Rep*, 10(1):37–51. doi:10.1179/135100005X21606 PMID:15829110

Valavanidis A, Salika A, Theodoropoulou A (2000). Generation of hydroxyl radicals by urban suspended particulate air matter. The role of iron ions. *Atmos Environ*, 34(15):2379–86. doi:10.1016/S1352-2310(99)00435-5

van Eeden SF, Tan WC, Suwa T, Mukae H, Terashima T, Fujii T et al. (2001). Cytokines involved in the systemic inflammatory response induced by exposure to particulate matter air pollutants (PM_{10}). *Am J Respir Crit Care Med*, 164(5):826–30. doi:10.1164/ajrccm.164.5.2010160 PMID:11549540

van Houdt JJ, Alink GM, Boleij JSM (1987). Mutagenicity of airborne particles related to meteorological and air pollution parameters. *Sci Total Environ*, 61:23–36. doi:10.1016/0048-9697(87)90353-6

van Houdt JJ, Coenen PW, Alink GM, Boleij JS, Koeman JH (1988). Organ specific metabolic activation of five extracts of indoor and outdoor particulate matter. *Arch Toxicol*, 61(3):213–7. doi:10.1007/BF00316636 PMID:3355366

van Houdt JJ, Jongen WM, Alink GM, Boleij JS (1984). Mutagenic activity of airborne particles inside and outside homes. *Environ Mutagen*, 6(6):861–9. doi:10.1002/em.2860060612 PMID:6389111

van Maanen JMS, Borm PJA, Knaapen A, van Herwijnen M, Schilderman PA, Smith KR et al. (1999). In vitro effects of coal fly ashes: hydroxyl radical generation, iron release, and DNA damage and toxicity in rat lung epithelial cells. *Inhal Toxicol*, 11(12):1123–41. doi:10.1080/089583799196628 PMID:10562700

Vellosi R, Vannucchi C, Bianchi F, Fiorio R, Rosellini D, Ciacchini G et al. (1994). Mutagenic activity and chemical analysis of airborne particulates collected in Pisa (Italy). *Bull Environ Contam Toxicol*, 52(3):465–73. doi:10.1007/BF00197838 PMID:7511445

Vergé X, Chapuis A, Delpoux M, Dulieu H, Fabre A, Meybeck MP (2004). Tobacco plants detect a decrease of environmental genotoxicity in Toulouse (France). *Environ Monit Assess*, 91(1–3):199–209. doi:10.1023/B:EMAS.0000009236.60235.bf PMID:14969444

Verma V, Polidori A, Schauer JJ, Shafer MM, Cassee FR, Sioutas C (2009). Physicochemical and toxicological profiles of particulate matter in Los Angeles during the October 2007 southern California wildfires. *Environ Sci Technol*, 43(3):954–60. doi:10.1021/es8021667 PMID:19245042

Verma V, Rico-Martinez R, Kotra N, King L, Liu J, Snell TW et al. (2012). Contribution of water-soluble and insoluble components and their hydrophobic/hydrophilic subfractions to the reactive oxygen species-generating potential of fine ambient aerosols. *Environ Sci Technol*, 46(20):11384–92. doi:10.1021/es302484r PMID:22974103

Vesterdal LK, Jantzen K, Sheykhzade M, Roursgaard M, Folkmann JK, Loft S et al. (2012). Pulmonary exposure to particles from diesel exhaust, urban dust or single-walled carbon nanotubes and oxidatively damaged DNA and vascular function in *apoE*$^{-/-}$ mice. *Nanotoxicology*, 8(1):61–71. doi:10.3109/17435390.2012.750385 PMID:23148895

Viau CJ, Lockard JM, Enoch HG, Sabharwal PS (1982). Comparison of the genotoxic activities of extracts from ambient and forest fire polluted air. *Environ Mutagen*, 4(1):37–43. doi:10.1002/em.2860040106 PMID:7040069

Villalobos-Pietrini R, Amador-Muñoz O, Waliszewski S, Hernández-Mena L, Munive-Colín Z, Gómez-Arroyo S et al. (2006). Mutagenicity and polycyclic aromatic hydrocarbons associated with extractable organic matter from airborne particles ≤10 μm in southwest Mexico City. *Atmos Environ*, 40(30):5845–57. doi:10.1016/j.atmosenv.2006.05.009

Villalobos-Pietrini R, Blanco S, Gomez-Arroyo S (1995). Mutagenicity assessment of airborne particles in Mexico City. *Atmos Environ*, 29(4):517–24. doi:10.1016/1352-2310(94)00247-I

Villalobos-Pietrini R, Blanco-Jimenez S, Gomez-Arroyo S (1999). Direct- and indirect-acting mutagens of airborne particles from south-western Mexico City *Toxicol Environ Chem*, 70(1–2):103–13. doi:10.1080/02772249909358743

Villalobos-Pietrini R, Hernández-Mena L, Amador-Muñoz O, Munive-Colín Z, Bravo-Cabrera JL, Gómez-Arroyo S et al. (2007). Biodirected mutagenic chemical assay of PM_{10} extractable organic matter in southwest Mexico City. *Mutat Res*, 634(1–2):192–204. doi:10.1016/j.mrgentox.2007.07.004 PMID:17720617

Villarini M, Fatigoni C, Dominici L, Maestri S, Ederli L, Pasqualini S et al. (2009). Assessing the genotoxicity of urban air pollutants using two in situ plant bioassays. *Environ Pollut*, 157(12):3354–6. doi:10.1016/j.envpol.2009.09.012 PMID:19836119

Vineis P, Hoek G, Krzyzanowski M, Vigna-Taglianti F, Veglia F, Airoldi L et al. (2006). Air pollution and risk of lung cancer in a prospective study in Europe. *Int J Cancer*, 119(1):169–74. doi:10.1002/ijc.21801 PMID:16463382

Vinitketkumnuen U, Kalayanamitra K, Chewonarin T, Kamens R (2002). Particulate matter, PM_{10} & $PM_{2.5}$ levels, and airborne mutagenicity in Chiang Mai, Thailand. *Mutat Res*, 519(1–2):121–31. doi:10.1016/S1383-5718(02)00130-4 PMID:12160897

Viras LG, Athanasiou K, Siskos PA (1990). Determination of mutagenic activity of airborne particulates and of the benzo[α]pyrene concentrations in Athens atmosphere. *Atmos Environ Part B Urban Atmos*, 24(2):267–74. doi:10.1016/0957-1272(90)90032-P

Walker RD, Connor TH, MacDonald EJ, Trieff NM, Legator MS, MacKenzie KW Jr et al. (1982). Correlation of mutagenic assessment of Houston air particulate extracts in relation to lung cancer mortality rates. *Environ Res*, 28(2):303–12. doi:10.1016/0013-9351(82)90129-3 PMID:6749487

Wang CY, Lee MS, King CM, Warner PO (1980). Evidence for nitroaromatics as direct-acting mutagens of airborne particulates. *Chemosphere*, 9(2):83–7. doi:10.1016/0045-6535(80)90093-4

Wang MR, Wang WD, Liang J (1993). *Research on mutagenicity of organic chemicals in airborne total suspended particulates (TSP) in Daqing area (petroleum factory)*. Environmental Protection of Oil & Gas Fields.

Wang XZ, Zhang YE (1984). The mutation test research on the indoor air pollutants and the outdoor ones. *J Harbin Med Univ*, 1:56–61.

Watterson TL, Sorensen J, Martin R, Coulombe RA Jr (2007). Effects of $PM_{2.5}$ collected from Cache Valley Utah on genes associated with the inflammatory response in human lung cells. *J Toxicol Environ Health A*, 70(20):1731–44. doi:10.1080/15287390701457746 PMID:17885930

Watts R, Fitzgerald B, Heil G, Garabedian H, Williams R, Warren S et al. (1989). Use of bioassay methods to evaluate mutagenicity of ambient air collected near a municipal waste combustor. *JAPCA*, 39(11):1436–9. doi:10.1080/08940630.1989.10466636 PMID:2607359

Watts RR, Hoffman AJ, Wilkins MC, House DE, Burton RM, Brooks LR et al. (1992). Evaluation of high volume particle sampling and sample handling protocols for ambient urban air mutagenicity determinations. *J Air Waste Manage Assoc*, 42(1):49–55. doi:10.1080/1047328 9.1992.10466969 PMID:1575968

Wei YH, Chang KT, Chiang PC, Chang SC (1991). Analysis and tracing of polycyclic aromatic hydrocarbons and mutagenicity of airborne particulates from the Taipei area. *Proc Natl Sci Counc Repub China B*, 15(1):53–62. PMID:1946812

Wessels A, Birmili W, Albrecht C, Hellack B, Jermann E, Wick G et al. (2010). Oxidant generation and toxicity of size-fractionated ambient particles in human lung epithelial cells. *Environ Sci Technol*, 44(9):3539–45. doi:10.1021/es9036226 PMID:20355702

White PA, Rasmussen JB, Blaise C (1995). Genotoxicity of snow in the Montreal metropolitan area. *Water Air Soil Pollut*, 83(3–4):315–34. doi:10.1007/BF00477360

Whittaker A, BéruBé K, Jones T, Maynard R, Richards R (2004). Killer smog of London, 50 years on: particle properties and oxidative capacity. *Sci Total Environ*, 334–335:435–45. doi:10.1016/j.scitotenv.2004.04.047 PMID:15504529

Whong WZ, Stewart J, McCawley M, Major P, Merchant JA, Ong T-M (1981). Mutagenicity of airborne particles from a nonindustrial town. *Environ Mutagen*, 3(6):617–26. doi:10.1002/em.2860030604

Wise H, Balharry D, Reynolds LJ, Sexton K, Richards RJ (2006). Conventional and toxicogenomic assessment of the acute pulmonary damage induced by the instillation of Cardiff PM_{10} into the rat lung. *Sci Total Environ*, 360(1–3):60–7. doi:10.1016/j.scitotenv.2005.08.056 PMID:16597461

Wolff GT, Siak JS, Chan TL, Korsog PE (1986). Multivariate statistical analyses of air quality data and bacterial mutagenicity data from ambient aerosols. *Atmos Environ Part A Gen Top*, 20(11):2231–41. doi:10.1016/0004-6981(86)90314-8

Wu YS, Fang G-C (2001). Mutagenicity and PAH-analysis of airborne particulate matter in rural site of central Taiwan, Sha-Lu *Toxicol Environ Chem*, 80(3–4):217–25. doi:10.1080/02772240109359012

Wullenweber M, Ketseridis G, Xander L, Ruden H (1982). Seasonal variations in the mutagenicity of urban aerosols, sampled in Berlin (West), with *Salmonella typhimurium* TA 98 (Ames test). *Staub Reinhalt Luft*, 42:411–5.

Wullenweber M, Xander L, Ketseridis G, Schleibinger H, Rüden H (1984). Mutagenic activity of airborne particulates sampled in Berlin (West). *J Aerosol Sci*, 15(3):431–4. doi:10.1016/0021-8502(84)90136-8

Xiao ZH, Shao LY, Zhang N (2009). A toxicological assessment of PM_{10} in Lanzhou: results from plasmid DNA assay. *China Environ Sci*, 29:561–6.

Yamaguchi T, Yamazaki H, Yamauchi A, Kakiuchi Y (1994). Mutagenicity of airborne particulates in a roadside atmosphere. *Jpn J Toxicol Environ Health*, 40(6):542–9. doi:10.1248/jhs1956.40.542

Yang W, Lu YT (1989). Mutagenicity of airborne particulate from Kumming by *Drosophila melanogaster* sex-linked recessive lethal (SLRL) test. *J Environ Health*, 6:13–5.

Yang WM, Wu BY, Ma YP (1994). Content of PAHs in different diameter airborne particles and relationship with their mutagenicity. *J Environ Health*, 11:10–3.

Yauk C, Polyzos A, Rowan-Carroll A, Somers CM, Godschalk RW, Van Schooten FJ et al. (2008). Germline mutations, DNA damage, and global hypermethylation in mice exposed to particulate air pollution in an urban/industrial location. *Proc Natl Acad Sci U S A*, 105(2):605–10. doi:10.1073/pnas.0705896105 PMID:18195365

Yauk CL, Fox GA, McCarry BE, Quinn JS (2000). Induced minisatellite germline mutations in herring gulls (*Larus argentatus*) living near steel mills. *Mutat Res*, 452(2):211–8. doi:10.1016/S0027-5107(00)00093-2 PMID:11024480

Yauk CL, Quinn JS (1996). Multilocus DNA fingerprinting reveals high rate of heritable genetic mutation in herring gulls nesting in an industrialized urban site. *Proc Natl Acad Sci U S A*, 93(22):12137–41. doi:10.1073/pnas.93.22.12137 PMID:8901546

Yi S, Zhang F, Qu F, Ding W (2014). Water-insoluble fraction of airborne particulate matter (PM_{10}) induces

oxidative stress in human lung epithelial A549 cells. *Environ Toxicol*, 29(2):226–33. doi:10.1002/tox.21750 PMID:22331617

Yu ZY, Zhu HG, Jiang SH (1989). An investigation of mutagenicity of airborne particles in a gaswork in Shanghai. *J Health Toxicol*, 3:239–41.

Yuan FS, Xun Q (1994). Study of unscheduled DNA synthesis in human amnion cell FL induced atmospheric particles. *J Prev Med Chin People's Liberation Army*, 12:274–6.

Yuan FS, Xun Q, Ma YP (1994). Unscheduled DNA synthesis induced in human amnion cell FL by various-size atmospheric particles. *J Environ Health*, 11:49–51.

Zhang W, Lei TA, Lin ZQ, Zhang H-S, Yang D-F, Xi Z-G et al. (2011). Pulmonary toxicity study in rats with PM_{10} and $PM_{2.5}$: differential responses related to scale and composition. *Atmos Environ*, 45(4):1034–41. doi:10.1016/j.atmosenv.2010.10.043

Zhang Y, Schauer JJ, Shafer MM, Hannigan MP, Dutton SJ (2008). Source apportionment of in vitro reactive oxygen species bioassay activity from atmospheric particulate matter. *Environ Sci Technol*, 42(19):7502–9. doi:10.1021/es800126y PMID:18939593

Zhang YL, Wang MR, Liang J (1991). Research on mutagenicity of organic chemicals in airborne particulates in Daqing area (petroleum factory). *Heilongjiang Environ J*, 1:6–11.

Zhao X, Wan Z, Chen G, Zhu H, Jiang S, Yao J (2002). Genotoxic activity of extractable organic matter from urban airborne particles in Shanghai, China. *Mutat Res*, 514(1–2):177–92. doi:10.1016/S1383-5718(01)00338-2 PMID:11815256

Zhao XS, Zhu HG (1996). The effect of organic extract from TSP on unscheduled DNA synthesis in primary rat liver cells. *J Environ Health*, 13:105–7.

Zhao XS, Zhu HG (1997). Mutagenicity of airborne particles after sub-fractionation. *Carcinog Teratog Mutagen*, 9:204–8.

Zhao XS, Zhu HG, Jiang SH, Yao JQ (1996). The mutagenic study of organic extract of suspended particulates in Shanghai. *Carcinog Teratog Mutagen*, 8:78–84.

Zhao ZH, Zhang XQ, Xu ZF, He DW (1983). Separation and mutagenicity of organic fractions of airborne particulates. *Acta Scientiae Circumstantiae*, 3:335–45.

Zhu HG, Zhao QY, Iang S (1991). Mutagenicity research on ambient suspended particulates in Shanghai *Shanghai Environ Sci.*, 10:10–4.

Zhu HG, Zhao QY, Jiang SH (1990). Mutagenicity study on different organic fractions of air particulate extract. *Shanghai Environ Sci*, 9:18–23.

Zwodziak J, Jadczyk P, Kucharczyk J (2001). Seasonal variability of the mutagenicity of airborne particles in the town center. *J Aerosol Sci*, 32(3):409–23. doi:10.1016/S0021-8502(00)00082-3