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Ground-level ambient particulate matter (PM) is important indicator for public health risks, especially its fine fraction (PM<sub>2.5</sub> - particles smaller than 2.5  $\mu\text{m}$ ). PM concentrations, size distributions and composition exhibit spatio-temporal dynamics at urban and diurnal scales, respectively. Size resolved concentrations peak at both day and evening hours and can vary between adjacent neighborhoods. At present, monitoring of ambient air quality is mainly achieved by point sampling in sparse ground stations, therefore do not provide detailed and spatial information regarding PM attributes. As an alternative, remote sensing (RS) techniques retrieve properties of the aerosols in an open path by measuring radiation response to PM at several wavelengths or angles in the visible-NIR range (400-1200 nm). Most aerosol RS techniques rely on solar radiation and therefore are limited to daytime.

Our study objective was to develop a versatile ground remote sensing procedure for monitoring size resolved concentrations of fine aerosols along urban scale open paths. A ground hyperspectral camera was implemented to acquire signatures (170 response channels in between 400-1100 nm) of PM size-modals between 0.2-2  $\mu\text{m}$ . A night-time imaging procedure was developed to acquire emission of remote artificial illumination, such as street lamps, instead of commonly used solar reflectance from land cover targets. In particular, halogen illumination was experimented, providing sensitivity to signatures of fine aerosol optical thickness (AOT). Such procedure offers a new concept for simultaneous measurements of aerosols in multiple ambient air columns under scarce solar radiation conditions.

The concept was validated by laboratory scale measurements of controlled aerosol concentrations that yielded expected AOT signatures according to Mie calculations. A field study was then conducted to develop a nighttime imaging procedure and assess its AOT detection limits. The procedure was used to predict concentrations of a controlled urban-like aerosol in ambient conditions. Urban-scale imaging was also applied to measure 1 km open path in Haifa city during different aerosol events between May 2010 and January 2011. Resulting AOT signatures demonstrate dominant aerosol size modal smaller than 500 nm and point out diversity of size distributions and composition, which should further be retrieved.

# **Adsorption and Desorption Of Environmental Tobacco Smoke (ETS) in Indoor Environment.**

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One of the major pollutants in indoor environment is environmental tobacco smoke (ETS), it has harmful health effects on both, active and passive smokers and may continue to effect, even long after a cigarette is extinguished. This later effect is termed “thirdhand smoke” (THS).

Many models try to predict ETS fate in indoor environment, but most of them do not consider its sorption under different environmental condition, on different surfaces and heterogeneous reactions of ETS compounds. This is in part due to current lack of quantitative information regarding the affect of such parameters on nicotine sorption and reactivity.

This research investigates ETS sorption and desorption on cotton, as representative of clothes, and common surface indoors, under different air exchange rates (AER). The focus is on nicotine, as common trace for ETS.

Sorption experiments of nicotine on cotton indicate that its initial sorption rate is not very sensitive to AER (between 0.4-1.5 h<sup>-1</sup>) and is slightly enhanced under high relative humidity. Desorption of ETS from cotton is fast (t<sub>1/2</sub>~minutes), but a significant residue of nicotine, that defuses deeper into the cotton, remains on the surface for longer time.

This research provides specific kinetics constants regarding ETS interaction with different indoor surfaces. The obtained date will increase the understanding of ETS behavior in indoor environment, and will help to improve mathematical models for predicting its levels following smoking in indoor settings.

# **A Comparison of Air Pollutant Emissions from Urban Buses and Passenger Cars in Israel**

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The problem of air pollution by motor vehicles is becoming increasingly acute worldwide and in Israel as well. Vehicle emissions that include particles and harmful gases negatively influence the cardio-vascular, respiratory and immune systems, thus increasing the risk of stroke and cancer development. Nano-particles are found to be penetrating through the blood cells into the human brain, liver etc with respective negative health effects.

The public transportation in Israel uses mostly buses with diesel engines. The higher thermodynamic efficiency of those engines leads to the emission reduction of greenhouse gases, such as CO<sub>2</sub>, together with CO and HC as compared to a gasoline-based engine. On the other hand, the NO<sub>x</sub> and PM emissions of diesel engines are higher.

The comparison of emissions by urban buses and passenger cars is performed based on assessment of emission factors with aid of ARTEMIS model. The latter was developed in a European research program with participation of the Technion's researchers. The model considers various parameters affecting vehicle emissions, such as: vehicle fleet composition, driving patterns, atmospheric conditions, engine technical generations (Euro 0 to Euro 5), fuel quality etc.

The results are the emission factors (EF), in units of g/(veh·km), and emissions inventory of the air pollutants such as CO, HC, NO<sub>x</sub>, PM for different types, classes and generations of vehicles.

Taking into account the average number of passengers is found that an urban bus pollutes 2.3-2.8 times less than a passenger car. To have a same level of pollution per passenger, a bus has to carry circa 24-28 passengers. The results allow a new and better evaluation of air pollution as a result of the traffic activity inside urban areas in Israel, and the exposure of the population in urban areas to it.

# Photochemical degradation of Chlorpyrifos

## Rates and implications to its environmental fate

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**Background:** Most of the available knowledge about the environmental fate of pesticides focuses on their degradation in bulk water or in soil. Recently, it became known that photo-oxidation reactions of pesticides that come in contact with the atmosphere can be very important in order to understand their environmental fate. In addition, previous studies have focused on the parent compound and not on its derivatives.

**Aims:** This research focuses on the organophosphate pesticide Chlorpyrifos, which is widely used in agriculture and the urban environment. The degradation of pesticides as a result of exposure to sun irradiation and oxidizing agents, while absorbed on hydrophilic or hydrophobic surfaces, was tested.

**Methods:** Slides were placed on temperature controlled bars, while on each slide a pesticide sample was deposited. Bar A was exposed to direct sunlight and to the atmosphere, while bar B was covered and exposed only to the atmosphere. In each experiment the solar flux was measured in order to compare and to calculate the quantum yield for Chlorpyrifos direct photochemistry, for these calculations, the absorbance of absorbed Chlorpyrifos was also measured. Analytical and commercial Chlorpyrifos were tested, as well as a derivative: Chlorpyrifos-Oxon.

**Results:** Our results show that photo degradation of absorb analytical Chlorpyrifos is quite fast, with half life of 1.3 hours ( $\Phi=0.023$  Molec/photons – quantum yield). While that of commercial Chlorpyrifos is faster, but with the same quantum yield ( $\Phi=0.027$ ). The derivative Chlorpyrifos-Oxon is less sensitive to photo-oxidation ( $\Phi=0.0007$ ), and as such is more likely to remain longer on open atmosphere surfaces. These results imply that Chlorpyrifos-Oxon is more likely to be found on aerosols from treated fields. Indeed, air samples from nearby Chlorpyrifos treated field were found to contain Chlorpyrifos-Oxon.

**Conclusions:** This research shows that in order to understand the fate of pesticides in the environment the degradation on surfaces should also be taken into consideration.

# **A sentinel case series of cancer patients with occupational exposures to electromagnetic non-ionizing radiation with short latent periods**

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**Background:** We have reported groups of workers with high exposures to Non-Ionizing Radiation and short latent periods for cancer. We present a sentinel case series (n=47, 40M, 7F) of self-referred cancer patients with occupational exposures to EMF.

**Objectives:** To report ages of first diagnosis/latency and tumour type and exposures

**Methods:** We categorized patients with regard to types of radiation, far or near field exposure and direct body contact, age of diagnosis and latency. For some we had data on frequencies, for others we provided assessments.

**Results:** 15 patients developed cancer with latent periods < 5y and 12 patients with latent periods between 5y and 10y. The remaining 20 patients had longer latent periods. In the <5y latency group there were 8 hematolymphatic cancers and 9 solid tumours – testis, head & neck (including brain) and GI tract. In both the <5y and 5-9y latency groups there were patients exposed to intense levels of EMF, to several frequencies of EMF, or to EMF in combination with IR or other exposures. There were patients with direct body contact, or were in direct line of focus from point sources, or worked in small, electronically dense environments. In the >10y latency group there were more patients with intermittent exposures or exposures at older ages.

**Discussion:** The data suggest that cancer in young workers may be associated with intense severe exposures to EMF and short latent periods, especially for hematolymphatic cancers. The findings state the case for (1) more careful modelling of exposure sources and penetration into the body, (2) preventive and protective measures based on control of exposure at source, barriers, and personal protection and (3) exploring low-exposure-low risk relationships for latent periods <10 y.

# Particulate Air Pollution has a Metal Mediated Cytotoxic Effect Detected by Whole Cell Bacterial Reporters

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Numerous studies have demonstrated that elevated concentrations of suspended atmospheric particulate matter (PM) are associated with adverse health effects. In order to minimize the adverse public health effects of atmospheric PM by exposure management, there is a need for a greater understanding of the toxic mechanisms and PM components that are liable for the toxic effects. The aim of this study was to utilize bioassay techniques to investigate these aspects. For this purpose a reporter panel of genetically engineered bacterial (*Escherichia coli*) strains was composed. Each panel member was designed to report on a different stress condition with a measurable light signal produced by the luciferase enzyme.

Toxic mechanisms and components were studied using five anthropogenic PM source samples, including two vehicle combustion particles and three coal fly ash (CFA) samples. The most prominent outcome of the panel exposure results were broad panel responses observed for two of the CFA samples, indicating oxidative stress, respiration inhibition and iron deficiency. These responses were relieved when the samples were treated with EDTA, a non-specific metal chelator, suggesting the involvement of metals in the observed effects. An elemental composition and bioavailability analyses of the samples suggest that chromium was related to the toxic responses induced by two of the CFA samples.

The redox activity of the same samples was assessed by a chemically based assay, the DTT assay. No correspondence between the panel's responses and the outcomes of the DTT assay were observed, emphasizing the complexity of bio-toxicity and the importance of integrating bioassays in PM toxicity studies.

The reporter panel approach, as demonstrated in this study, has the potential of providing novel insights as to the mechanisms of atmospheric PM toxicity. Furthermore, combining the panel's results with bioavailability data can enlighten about the role of different PM components in the observed toxicity.

# Association between congenital heart defects and maternal exposure to ambient air pollution and temperature in an Israeli birth cohort, 2000-2006.

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**Background and Aims:** There are new concerns that air pollution may play a role in the causation of congenital anomalies, and such an effect is of public health importance. A recent meta-analysis reported evidence for an effect of ambient air pollutants (AP) on Congenital Heart Defect (CHD) risk. The potential influence of direct temperature effects on pregnancy outcomes is an area of emerging research. Therefore we examined associations between CHD and maternal exposure to ambient AP and temperature in an Israeli birth cohort.

**Methods:** We conducted a registry-based cohort study on 138,675 newborns in Tel-Aviv region during 2000-2006. For each pregnant woman we used GIS to assess personal exposure to carbon monoxide, nitrogen dioxide, ozone, sulfur dioxide, particulate matter (PM<sub>10</sub> and PM<sub>2.5</sub>) during weeks 3-8 of pregnancy; using inverse distance weighting method. In addition ambient temperature was considered. Logistic models were conducted to compare exposure levels between the 2087 CHD cases and the non-cases, adjusted for socio-demographic covariates and season.

**Results:** Comparing the highest quartile of exposure with the lowest, we found positive associations between PM<sub>10</sub> and total CHD (OR 1.34, 95% CI: 1.14, 1.57), Patent ductus arteriosus (PDA) (OR 1.53, 95% CI: 1.10, 2.12) and atrial septal defects (ASD) (OR 1.30, 95% CI: 1.04, 1.61). We also found a positive association between ambient temperature and increase risk in all CHD groups tested [total CHD (OR 1.44, 95% CI: 1.16, 1.78), PDA (OR 1.56, 95% CI: 1.01, 2.41), ASD (OR 1.45, 95% CI: 1.08, 1.94) and ventricular septal defects (OR 1.69, 95% CI: 1.14, 2.50). These associations corroborated the continuous models. An inverse associations between PM<sub>2.5</sub> and all CHD group tested was observed.

**Conclusions:** The results for PM<sub>10</sub> support previously reported associations. Positive relationship between ambient temperature exposure and CHD risk found in this study are biologically plausible, and may be important if temperatures increase due to climate change.

# Cumulative exposure to air pollution, socioeconomic status and post-myocardial infarction outcomes in central Israel. A cohort study

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**Objective:** In a community-based cohort of myocardial infarction (MI) survivors, we examined whether cumulative residential exposure to air pollutants constitutes a risk factor for adverse outcomes.

**Methods:** Patients aged  $\leq 65$  years ( $n=1,428$ ), admitted with first MI in 1992-1993 to the 8 hospitals serving the population of central Israel, were followed through 2005. Extensive data were collected on socio-demographic, clinical, and environmental factors. Daily measures of nitrogen dioxide (NO<sub>2</sub>), nitric oxide (NO) and particles less than 2.5 micrometers in diameter (PM<sub>2.5</sub>) recorded at air quality monitoring stations were summarized and cumulative exposure was estimated for each patient based on geo-coded residential location at study entry. Cox models were used to assess the hazard ratios (HRs) for all-cause death, cardiac death, recurrent MI, heart failure and ischemic stroke associated with a 10  $\mu\text{g}/\text{m}^3$  increase in pollutant exposure.

## Results:

Patients residing in more polluted areas had better socioeconomic status at both the individual and neighborhood levels. Exposure to pollutants was inversely associated with outcomes. However, these associations were either removed or reversed upon multivariable adjustment for socioeconomic and clinical variables (HRs [95% CIs] of PM<sub>2.5</sub> are reported in the Table).

## Conclusion:

In this unique setting and in contrast to other reports, better socioeconomic status was associated with higher exposure to pollution. In multivariable-models accounting for socioeconomic and clinical variables, we observed a weak positive association between PM<sub>2.5</sub> exposure and post-MI outcomes, consistent with findings in the general population. Given the likelihood of exposure misclassification we believe the true association is substantially stronger.

	Unadjusted	Multivariable-Adjusted
All-Cause Death	0.93 (0.53-1.62)	1.51 (0.85-2.67)
Cardiac Death	0.74 (0.38-1.44)	1.37 (0.70-2.68)
Recurrent MI	1.06 (0.62-1.81)	1.67 (0.96-2.92)
Heart failure	0.60 (0.32-1.12)	1.39 (0.73-2.62)
Stroke	0.64 (0.29-1.40)	1.04 (0.46-2.33)

## Neurobehavioral effects in schoolchildren chronically exposed to environmental pesticides

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### **Background and Aims:**

Previous studies by our group (1987-1991) showed in-season reversible neurobehavioral effects of low-level, long-term exposure to pesticides in residents in rural communities in Northern Israel. This study was designed to assess the neurobehavioral and cognitive effects in 8-12 years-old schoolchildren in the same communities. Eighty-four percent of these schoolchildren are the "second generation" exposed to pesticides, given that at least one of their parents has been residing in this rural area for at least three decades and chronically exposed to pesticides. The studied group included two sub-groups: 51 children who reside and attend school in an exposed valley; and 45 children residing on the hills around the valley and attend school in the valley. The control group included 40 age- and sex- matched children residing in a different rural area in which the use of pesticides is restricted ("organic agriculture") for several decades.

**Methods:** Parents' questionnaire which included exposure assessment and Inattention Hyperactivity Questionnaire derived from DSM-4. Neurobehavioral tests included Trail Making Tests A and B, Digit Cancellation, arithmetic and Diamond tests, as well as Purdue Pegboard for manual dexterity.

**Results:** The performance of Trail Making (A and B), Digit Cancellation and Diamonds Tests showed pesticides exposure-effect gradient. In a like manner, Purdue Pegboard showed an exposure-effect gradient in the manual dexterity in both hands and in the sub-dominant hand as well. The parents' exposure assessment and Inattention and Hyperactivity Questionnaire indicated a similar gradient between children's exposure to pesticides and their inattention and hyperactivity.

**Conclusions:** Neurotoxic effects of chronic exposure of children to pesticides were manifested in their executive skills, first and foremost in their attention span, visual scanning and execution speed. There may be environmental-susceptibility interactions and epigenetic effects expediting the occurrence of ADHD in children with low-level endemic exposure to pesticides.

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## Health risks associated with greywater reuse

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As water availability declines, on-site use of greywater (GW) for irrigation is a growing practice. Alongside with its advantages, it might pose health risks such as spread of pathogens. The level of health risk is determined by the GW quality and the extent of exposure. GW samples from 36 households around Israel were collected and analysed for physicochemical and microbial parameters. The exposure level was assessed by questionnaire and data from the literature. Moreover, the effect of different water treatments, design attributes, and GW sources was statistically assessed. Based on the microbial data and questionnaire quantitative microbial risk assessment (QMRA) was conducted under different GW reuse scenarios for Rotavirus, *Pseudomonas aeruginosa*, and *Staphylococcus aureus*. The type of GW treatment as well as the water source (specifically from the kitchen) had a significant effect on the GW quality. Using a literature based correlation between Rotavirus and *E. Coli*, it was postulated that for a single household reuse scheme, a maximum level of  $10^2$  *E. coli* CFU/100 ml is safe based on the World Health Organization acceptable risk for Rotavirus infection. To reduce exposure level and consequently the risk, barriers such as use of drip and sub-surface irrigation as well as prohibition of irrigation of vegetables that are consumed raw should be used. Additionally, wearing gloves and washing hands when there is direct contact with GW serve as important measures to reduce the extent of exposure. A similar approach should be taken towards the establishment of quantitative risk assessment for environmental pollutants such as salinity, organic matter, and metals.

## ***Ambrosia* spp. In Israel: An allergenic invasive plant**

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The genus *Ambrosia* spp. (Ragweed) is a member of the *Asteraceae* family and includes over 40 species. The invasive plant originates from north-America and grows now in Europe, Asia and Australia and Israel. The most common species in Israel are perennials - *Ambrosia confertiflora* and *A. tenuifolia*, whereas in North America and Europe the major ragweeds are annuals - *A. artemisiifolia* and *A. trifida*. The *Ambrosia* pollen grains are well known for their high allergenic effects causing “hay fever” that impacts more than 15 million people in the USA. Global climate changes may cause these plants to extend and enlarge their distribution and lengthen their flowering time, producing much larger amounts of highly allergenic pollen. It is still unclear if the *Ambrosia* species growing in Israel are allergenic as well: it is our main research question along with elucidation of their life cycle under Israel conditions. We also exploring better and more efficient practices for *Ambrosia* management in agricultural and public domains. The rapid spread of the *A. confertiflora* and *A. tenuifolia* is attributed to their efficient vegetative reproduction by rhizome and large amounts of seed production. Our experiment showed that a single pot of dry soil taken from the vicinity of wild plants grew into 50 mature plants within just one month, later propagating into 672 plants during 5 months. It appears that the *Ambrosia* invaded Israel via contamination of imported grains for feed and further spread along streams, rivers and railway tracks and by the movement of contaminated soil. Our presentation will describe the current distribution of *Ambrosia* spp. in Israel, including phenology, morphology and physiology of the various species and the allergic reaction to pollen extracts and a comparison of sensitivity to different *Ambrosia* species to control measures.

# Spatial dispersion of respiratory diseases and meteorological air pollution and socio-economic factors in Israel's Negev Desert

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**Background and Aims:** The potential effects of ambient air pollution and meteorological factors on health have received much attention over the past decades. Epidemiological studies have shown that even small increases in air pollution are associated with increased morbidity and mortality. The present study analyzes the association between geographical, meteorological, vehicular air pollution and socio-economic factors and respiratory diseases in Beer Sheva city, located in the northern part of the Negev desert.

**Methods:** 1. GIS and spatial statistics to analyze the spatial distribution of respiratory diseases in Beer Sheva. 2. Vehicular air pollution dispersion model (AERMOD software) to receive spatial exposure proxy of NO<sub>x</sub> and PM<sub>2.5</sub>. 3. Negative binominal generalized linear models and special time series techniques to analyze the association of short term meteorological, vehicular air pollution and socioeconomic factors and respiratory diseases.

**Results:** 1. highest seasonal monthly respiratory diseases hospitalization rate found in the central part of the city. 2. Highest hospitalization rates found during winter. Significantly different hospitalization rate by seasons found for all disease groups studied. 3. Association of meteorological factors (mean daily temperature and relative humidity) for the elderly (65+) and daily hospitalization rate found for respiratory diseases in 2003-2007. 4. Daily traffic related NO<sub>x</sub> is significantly associated with daily hospitalization rates of respiratory diseases.

**Conclusion:** 1. Proposed methodology for estimation of vehicular air pollution is effective; 2. Significant direct and indirect association between considered health outcomes, meteorological and vehicular air pollution factors were found; 3. Results suggest a new methodology for exposure: the use of air pollution dispersion models based on meteorological factors and vehicular emission data where no measured data exists

# Environmental Health Research with Civil Society Organizations

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Civil society organisations (CSOs) show an increasing interest in research conducted in fields such as sustainable development, food safety and public health - all which touch on issues of environment and health. CSOs are also sources of knowledge, know-how and innovations. Academic institutions have the capabilities to conduct the necessary research. The challenge is to create an interface that will enable joint work and mutual learning processes.

Many European countries have a model for such an interface: the 'Science Shop'. This is typically a unit in the university which responds to civil society's needs for expertise and knowledge by 'matching' questions raised by CSOs to students looking for dissertation topics.

The European experience proves that there are many advantages for research with CSOs. For students this is an opportunity to create knowledge with social impact and engage with practical problems. As a result, students learn to analyse complex problems with social and political aspects and to apply theoretical concepts in a practical context. They also experience work in (multi-disciplinary) teams and improve scientific communication skills. These are important skills for those who will work in the public sector or as consultants. For those planning a research career, the Dutch experience shows that ideas for original research often arise from discourse with CSOs.

In Israel this type of interface has yet to be institutionalised. However, established environmental and health organizations have an interest in applied and relevant research on subjects such as the exposure of food to environmental pollutants, the health effects of smoke from widespread garbage combustion or the effects of pesticide exposure on foreign workers.

The proposed poster will outline the benefits of research with CSOs and present potential subjects for research suggested by Israeli environmental and health organizations - research which may be conducted in cooperation with these organizations.

# **Surface aging of Chlorpyrifos under semiarid conditions and its impact on pesticide wash off from soil**

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In Israel, as in many other densely populated countries, it is very important to understand the factors affecting the emission of pesticides from agricultural fields due to their close proximity to settlements and/or water sources. For example, the watershed of Lake Kinneret is heavily cultivated, and hence, reducing pollution transport from the watershed to the lake is a national priority. Currently, available data on pesticides use refers only to the amount and time they are applied in the fields, but in fact, following their application pesticides attached on surfaces (leaves, top soil, etc.) may interact with atmospheric oxidants, and be subject to solar radiation yielding various degradation products. The physical and chemical properties of these degradation products may vary significantly from their parent compounds, which can considerably affect their health and environmental impact (some of them more toxic and/or less degradable than their parent compound). Much information can be found about degradation of pesticides in deep soil, but in semiarid areas when pesticide applied before the dry season most of the reactions occur on soil surface. Preliminary field measurements revealed that Chlorpyrifos and its main product TCP (3,5,6-Trichloro-2-Pyridinol) remain mainly on soil surface short period after application. In addition, Chlorpyrifos and TCP were found in streams around the agriculture area during the first rain events of the wet season. Despite the potential impact of pesticides' derivatives on human health and ecological systems, currently there is no comprehensive understanding of the dynamics of pesticides in agricultural fields.

The present research addresses this knowledge gap for a model pesticide (Chlorpyrifos, which is highly toxic and widely use in Lake Kinneret watershed), quantitatively investigating its fate, transport and transformations at the soil-surface. Important factor in semi-arid climate is aging, since the time from application of the pesticide until the first rains usually varies from 1 to 5 months. Adsorption/desorption tests were carried out for Chlorpyrifos and its main degradation products, and the effect of aging on desorption mechanism was investigated. Photochemical process that Chlorpyrifos and its daughter compounds undergo when adsorbed on surfaces and soils were also quantified

# Wireless Distributed Sensor Networks – A New Concept for Assessing Exposure

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As many cities around the world become more congested, concerns increase over the levels of urban air pollution and its impact on human health. Air Quality Monitoring (AQM) is essential to understand exposure patterns and to establish a link between exposure and health. The more the relationships between air pollution and different health outcomes are understood, the better the options there are for regulating, controlling and ultimately minimizing such effects. Yet, AQM networks require high installation and maintenance costs. These and other considerations limit the deployment of monitoring stations and therefore hamper the quality of spatial inference that can be obtained from the data. Wireless Distributed Sensor Networks (WDSNs) is an emerging concept that may overcome these limitations, thicken sensor deployment, ease sensor communications and data assembling, and enable dense measurement coverage at breathing height, i.e. useful for public health applications. The most flexible WDSNs are dynamic in the sense that they (a) contain mobile wireless sensor nodes, (b) are deployed ad-hoc, and (c) allow addition and deletion of sensor nodes after deployment to grow the network or replace failing and unreliable nodes. WDSNs include arrays of battery powered sensor nodes, have limited computational and memory capabilities, and rely on intermittent wireless communication via radio frequency. Deployment of a sensor grid is expected to create a wealth of data allowing new types of analysis, such as visualization of the spatiotemporal variation of multiple pollutants in respect to one another and studying their correlation with complementary data (e.g. micro-meteorology and traffic data). Moreover, the gathered data can be used for assessing exposure of pedestrians, drivers, and residents in the city. These analyses are expected to be obtained at an unprecedented spatial resolution, and be ready to use as possible risk metrics within environmental epidemiology and exposure studies.

# Assessing the Impact of Vehicular Transportation on NO<sub>x</sub>, PM<sub>2.5</sub> and PM<sub>10</sub> Concentrations in two Metropolitan Regions: A Case Study of Gush Dan and Haifa

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Nitrogen oxides (Nitrogen dioxide (NO<sub>2</sub>) and nitrogen monoxide (NO) and particulate matter (PM) are prevalent urban air pollutants. They have been linked to respiratory symptoms, cardiac disease, and premature death. Vehicular transportation is a dominant source of urban NO emissions, which rapidly undergo photochemical oxidation to form NO<sub>2</sub>, the pollutant of concern for its health effects. Due to its short atmospheric life time, NO is often used as a marker for transportation related pollution when measured at road side. On the other hand, it is known that transportation contributes to PM concentrations, but the extent and size fraction is less well understood. Unlike NO<sub>x</sub>, PM has an atmospheric life span on the synoptic scale. PM may therefore stem from local or long range anthropogenic and biogenic activities, making the sources and composition more complex to understand. Proper characterization of local PM composition, size fraction, and source are necessary for exposure and epidemiology studies, and for public policy.

The main goal of this work is to characterize the contribution of vehicular transportation to NO, NO<sub>2</sub>, PM<sub>2.5</sub> and PM<sub>10</sub> concentrations in the Gush Dan and Haifa Metropolitan regions in Israel, based on extensive air quality monitoring data. A methodology is proposed based on analysis of air quality monitoring data. NO is used as a marker for vehicular traffic and juxtaposed with PM data on various spatial and temporal scales.

A comparison of mean regional NO, NO<sub>2</sub>, and NO:NO<sub>2</sub> ratios in Haifa and Gush Dan reveals that Haifa experiences a background NO<sub>2</sub> level contributed by non-transportation sources, namely from the industry and power generation located in the Haifa Bay area. However, despite the presence of heavy industry and electricity generation in Haifa, NO<sub>x</sub>, PM<sub>10</sub> and PM<sub>2.5</sub> concentrations are significantly higher in Gush Dan, due to heavy traffic volume. Highly resolved temporal patterns reveal a strong traffic signature in NO<sub>x</sub> concentrations and NO:NO<sub>2</sub> ratios in both regions. NO<sub>2</sub> concentrations at roadside (RS) sites often exceed national ambient air quality standards, especially at peak rush hours, the very hours people are most exposed to air pollution. Long-term (5 year) averages reveal a decline in NO in both regions, however, NO<sub>2</sub> concentrations have been more difficult to reduce.

Particularly instructive in analysis of the effect of transportation at the micro-environment is a highly resolved spatial-temporal study conducted at one site which has both an ambient (AMB) monitor at rooftop, a road-side (RS) monitor, and a curbside (CS) monitor. CS concentrations reach 5 times the AMB concentrations during rush hours. This study proposes a conversion factor between AMB and RS NO<sub>x</sub> concentrations. Since most air quality monitors are placed on building rooftops, thus underestimating human exposure, such a conversion factor is necessary to optimally use monitoring data for exposure estimation.

Analyses of hourly and daily PM<sub>10</sub> and PM<sub>2.5</sub> averages indicate that heavy traffic may contribute up to ~20% of the observed PM. We find PM to vary significantly on the

intraurban spatial scale and on various temporal scales. A high correlation between the diurnal pattern of PM and NO was found in most locations. By studying a large sample of AQM stations over a long period of time, a correlation is detected between long term NO and PM concentrations over all stations. Weekend reductions in concentrations and in the coarse particle fraction indicate that transportation contributes more to PM<sub>10</sub> than to PM<sub>2.5</sub>.

Varying background PM confounds the ability to quantify the contribution of local sources to urban PM. However, the significant effect of local vehicular transportation can be detected. Since vehicle exhaust emissions contribute to the ultrafine particulate fraction, monitoring particle mass rather than number obscures this contribution. The increase that was found due to high traffic, on the order of magnitude of a few  $\mu\text{g}/\text{m}^3$ , may actually represent a large number of highly toxic particles and thus merits continued research and perhaps a conceptual change in monitoring techniques, with possible implications for ambient air quality standards.

# **The Coastal Boundary Layer and Air Pollution – A High Temporal Resolution Analysis in the East Mediterranean Coast**

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The East Mediterranean (EM) coast is characterized by warm sea temperatures and a nearly linear coastline. Both parameters influence the sea breeze front and the atmospheric conditions most relevant to air pollution dispersion. Here, the high resolution boundary-layer diurnal variation is highlighted leading to a distinct pattern of spatial-temporal air pollution dispersion, for over 25 years, from Israel's largest coal-fired power plant. Over 4,000 air pollution events were segregated by semi-objective synoptic systems and 7 years of boundary layer profiles carried out by acoustic radar. Results clarify why the highest air pollution events occur during summer at 12:00- 15:00 h through the average coincident drop of the boundary layer height down to 450 m above the ground. Here, the interaction between the synoptics and the sea-breezes is shown to play a significant role in the specific air pollution pattern.

# Classification of Dust Days over Israel by Integration of Satellite Remote Sensing Products

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The last decade has shown a considerable progress in satellite remote sensing of dust particles. From an environmental health perspective, such an event detection, after linking it to ground PM observations, can proxy acute exposure to respirable particles of certain properties (i.e. size, composition, toxicity). Being affected considerably by atmospheric dust, previous studies in the Eastern Mediterranean and in Israel in particular, focused on mechanistic and synoptic prediction, classification, and characterization of dust events, partially based on satellite observations. In particular, Ganor *et al* (2009) suggested a scheme for identifying dust days (DD) in Israel based on ground PM<sub>10</sub> measurements, validated by compositional analysis. This scheme requires information about ground PM<sub>10</sub> levels, which is clearly not available in places without ground monitoring coverage. In such cases satellite remote sensing products may be an efficient and cost-effective alternative to ground measurements. This work demonstrates a model to identify DD and Non-DD over southern Israel based on an integration of satellite products (AOD, SSA, AE, and AAI) from different satellite platforms (MODIS, OMI). We expect this model to enable environmental epidemiologists, as well as ecologists, to distinguish among health and environmental effects that result from exposure to dust events where ground monitoring data is sparse or missing.

## **Multiple dimensions of air quality in metropolitan areas - example from Montreal, Canada**

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In urban areas, air quality is the outcome of multiple emission sources, each emitting a different mix of air pollutants. The result is a complex mixture with a different spatiotemporal variability for each constituent.

This study examines the main complexities of urban air quality with respect to spatial differences for multiple pollutants at several spatial scales, so as to gain a better understanding of the variability in exposure estimates to multipollutants.

Mobile measurements of 23 air pollutants were taken at high resolution in Montreal, Quebec, Canada, during multiple days in 2009 and examined with respect to space, time and their interrelationships.

Results of the study show that sharp differences in the spatial distribution exist between pollutants on the intra-urban (i.e., quarters), sub-urban (i.e., neighborhood) and down to the single street scales. While some pollutants (e.g., Nitrogen Dioxide and Ultrafine Particles) are related with the roads network, others (e.g., Benzene and Toluene) also exhibit a connection to industrial or local sources. As a result, the multipollutant mix is changing considerably both in time and in space throughout the city. Although no single pollutant can be identified as a proxy for the entire mix, nitrogen oxides (NO, NO<sub>2</sub>, NO<sub>x</sub> and NO<sub>y</sub>) and ultrafine particles were found to be associated with most pollutants, and may be regarded as "best compromise" proxies.

