International Conference

Air Quality Innovation Programme / IPL (Innovatieprogramma Luchtkwaliteit)
Improving air quality along motorways

2009, November 25/26, World Trade Centre, Rotterdam

Introduction

Prof. Dr. Jos Arts, University of Groningen/Rijkswaterstaat (Chairman) and
Mrs. *C. Kempenaar*, IPL Programme-manager welcome all people present to this special conference. They are very happy with the great attendance.

You are kindly invited to download the sheets of all the presentations at www.ipluchtkwaliteit.nl.

Rijkswaterstaat, initiator of this conference, is the executive agency of the Dutch Ministry of Transport, Public Works & Water Management

The main goal of this IPL-conference is the dissemination of knowledge gained, sharing results and information and a maintaining momentum, follow-up.

IPL-features:
- Period of time: 2005 – 2010;
- Budget of € 20 million;
- 9 large scale field trials;
- 3500 meetings;
- 60.000 hours of the members of the IPL-team.

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Partnerships of IPL are:
- The government: Ministry of Transport, Ministry of Environment, local authorities
- The private sector: consultants, contractors
- Knowledge institutes: the national and international scientific community

Introducing speech by *H. Oliver Gao,* Cornell University, USA

The first Anti-Air Pollution Law was described a long time ago:

"Be it known to all within the sound of my voice, whosoever shall be found guilty of burning coal shall suffer the loss of his head." *Edward I (1273)*

And where are we now? 146 million people live in unhealthy air, primarily caused by ozone and particulate matter (PM). 160m tons of pollution is emitted into the air each year in the US. The trend for the future is not promising – people in the growing economies like India and China will all buy cars etc.

Important to mention is the tricky ozone pollution; ozone is the secondary pollutant. The paradox that we face is the so-called Ozone Weekend Effects: a higher weekend peak ozone in spite of reduced precursor (lower NOx). We don't fully understand why.

We need green technology, because we travel a lot and we can't stop that.

Question: Are the ozone concentrations in clear areas used as a reference for these numbers?
Answer: Yes, even ozone concentrations in National Parcs for example.

Session 1

Canopies and air treatments

Air pollution near tunnels and international research
by *Mr. Hans Huijben,* h3mhuijben Consultancy

Tunnels cause local air problems, investigated in several programmes.

Conclusions of the 3 most important investigations:
- Be aware of effects of measures on the overall environment;
- Dutch prescribed calculation methods seem to be not in accordance with the real situation, resulting in over-estimating concentrations, which results in expensive measures;
- Measures are expensive, be careful in using;
- Calculation models should take in account effects like jet stream, thermal influence, moving traffic, hourly based calculations.

Question: Dutch calculation standards seem to overestimate the problem, so is there actually no real problem?
Answer: There seems to be a real problem, we have to improve the measures.

Electrostatic concept BAM / TU Delft
by *Mr. Bob Ursem,* Delft University of Technology

A Fine Dust Reduction System (FDRS) by a nature-inspired particle-absorber (Seabuckthorn (duindoorn)). Dust movements (sand, salt and bio-particles) and even fog droplets were lifted due to the presence of seabuckthorn in the Dutch dunes.

An experiment was done in the Thomassentunnel, which had a good start and outcome: 60 % PM10 mass reduction is feasible for the future. A great perspective.

Question: What can you say about the impact on personal health?
Answer: The smaller the particles, the more dangerous the situation is (they go deeper into the lungs).

Electrostatic concept BAM (measurements, data-analysis, results)
by *Dr. Jan Duyzer,* TNO

The electrostatic concept to remove PM from tunnel air: a field test was done in the Thomassentunnel. The system used can be turned on and off.

Conclusion:
- Approach with internal tracer works well: small random error and small systematic errors;
- The effect of switching system on TEOM measurements are unclear, error could be large;
- The system seems to reduce PM-concentrations in the tunnel by 10-15%: significantly different from zero (paying attention to only random errors), the effect of the system on TEOM-measurements is not clear at this stage;
- Current effectivity of the system would lead to a reduction of 1-2 exceedance days at the Thomassentunnel and 4-10 exceedance days at the Beneluxtunnel, both in 2008.

Question: The system is based on static electricity, but cars also attract static. Does this influence the results?
Answer: We don't know this, thank you for the suggestion.

Question: After having collected the particles, how do you clean the plates?
Answer: They are cleaned the ordinary way, and the particles definitely don't go into the air again.

Session 2

Dynamic Traffic Management (DTM)

DTM and air quality in the Netherlands
by *Mr. Marko Ludeking,* Rijkswaterstaat

DTM is an optimization system of traffic flows through routing or banning traffic and regulating access (dynamically and temporarily).

Results of this study:
- The effect of DTM is limited and largely depending on current traffic emissions and traffic conditions;
- Traffic emissions are generally 5-15 µg/m3;
  - The DTM effect is 0,25-1,5 µg/m3
- DTM homogenizes traffic flows and can influence the amount of traffic (also banning participants like polluting heavy traffic)
  - There's little support for air quality measures
- DTM is a measure that influences traffic emissions, so it's a
  - 'No regret' measure
  - Can be carefully put in use (dynamic) and is (cost) effective
- But implementation DTM for air quality is not easy
  - Additional air quality and meteo information is necessary
  - Dynamics in traffic and air quality concentration makes it hard to give an accurate prediction
  - Standard emission modelling is not suitable to predict DTM effects accurately
  - Measuring and monitoring air quality effects has generally 1-2 µg/m3 inaccuracy, so the effect of DTM on air quality is statistically hard to measure.

Question: Reduction in speed from 100 → 80 km/h gives a reduction in emissions. Does a speed limit from 120 -> 80km/h give even more reduction?
Answer: Yes but much depends on police control, if there is no police control most people will not drive 80km/h on the highway.

Question: Did you look at highways before DTM was introduced?
Answer: Yes, at Rijkwaterstaat we did a lot of experiments with DTM so we know a lot about the side-effects of the system.

Session 3

Roadside vegetation

Measurements of PM_{10} and NO_2 & vegetation
by *Mr. Theo Cornelissen,* Rijkswaterstaat

Rijkswaterstaat did two measuring campaigns: at Valburg (A50), planted for this experiment and at Vaassen (A50) with existing vegetation.

Conclusions of the experiment:
- Close to the road: no change;
- 30 – 100 m from the road: slight improvement (if any effect);
- More than 100 m from the road: no change (slight improvement).

Recommendations:
- Improving the air quality directly along a highway: do not plant vegetation
- There is no reason to cut trees along highway

Don'ts
- Trees in a busy street and trees near sources with people there
- Screens near highway consisting of vegetation

Do's
- Trees in a quiet street and trees near sources without people there
- Screens along a highway covered with vegetation?
- Trees around the receiver
- Parks, woods
- Vegetation on roofs.

Question: Why were no pictures shown of the experiment on the A50? That experiment had different results.
Answer: The results were not contrary.

Question: Why not put trees on a distance of about 100 m from the highway, because of the turbulence effect?
Answer: That might be a good idea. Turbulence helps mixing dirty and fresh air.

Question: Did you investigate the effect of moss?
Answer: No, because moss is very low, no effect was expected.

CFD modelling of air pollution and vegetation
by *Dr. Stijn Janssen,* Vito

Vito (Vision on Techology) was asked to analyse the vegetation measurement.

They drew the following conclusions from it:
- Complex configurations can be described with CFD models such as ENVI-met
- There are two different effects on local air quality:
  - Deposition ☐ low
  - Aerodynamic effect ☐ high
    - Extra mixing with "fresh air" at higher levels
    - Effect depends on the "state" of the atmosphere

The general conclusion is:
- Close to the barriers there is a negative effect
- Behind the vegetation there sometimes is a local positive effect of 5 up to 10%.

Question: How about vegetation and electrostatic forces? Leaves can attract or repulse particles.
Answer: These kind of forces were not considered in these models. But there surely is deposition.

Question: How accurate are your measuring models?
Answer: We did some sensitivity tests, but you can never be sure how accurate a model really is.

Question: How can you put street canyons into your models?
Answer: It's simpler to mode street canyons then open air; in street canyons there is a more stable atmosphere.

Session 4

Road surfaces

Measurements with regard to application of $CaCl_2$ and road surface cleaning
by *Dr. Gijsjan van Blokland,* M+P

The road surface affects both the source and the propagation of PM_{10}.

Conclusions of the effect of road surface on PM_{10}:
- Significant effects in studied "full size" cases are hard to determine since:
  - local road traffic contributes only about 25% to the overall PM_{10} concentration
  - road surface-effect is a small portion of that fraction
  - continuous PM_{10} measurements exhibit relatively low accuracy
- Clear effect in full size testing found only for $CaCl_2$ spraying
- Clear effects found in simulated cases:
  - tyre wear on specific road surfaces
  - rolling resistance differs typically 30% peak-peak, leading to an estimated exhaust emission effect of 15%. Some low resistance roads are also found to exhibit low tyre wear
- There are strong indications that porous surfaces have positive effects due to buffering of fine dust particles.
- Studied data from other sources disagree strongly on the road wear contribution. We found no explanation for the different views.

Question: Did you measure the size of the distributed particles? This is very important from a health point of view.
Answer: We didn't measure the size.

Dust binding: practical trials in Sweden
by *Dr. Mats Gustafsson,* Swedish National Road and Transport Research Institute

Road dust is an important contributor to PM10 in Sweden due to road wear caused by studded tyres and winter maintenance.
The dust binders used in the experiment are CMA (calcium magnesium acetate), $CaCl_2$ (calcium chloride), $MgCl_2$ (magnesium chloride) and sugar solution.

The conclusions of the trials are:
- Dust binding effect:
  - The initial effect (ca 30-40%) and duration (4-5 days) was equal for all tested binders under current conditions
  - Effect duration was longer than reported from city street trials

- Friction reduction:
  - CMA > $MgCl_2$ = sugar > $CaCl_2$.

Recommendations:
- We recommend chlorides on roads where corrosion and environmental issues are not high priority, but CMA or sugar otherwise.
- The importance of friction reduction problems increases with speed and in sharp turns (e.g. roundabouts).
- SNRA will recommend $MgCl_2$ on their roads.

Question: Will magnesium chloride be the dominant matter in Sweden?
Answer: Not in cities, but on the highway yes it will be.

Question: Sugar, doesn't it rain away from the surface?
Answer: No, not more then other matter, but it smells and it gets onto cars (difficult to wash off).

Question: Do the roads get slippery after rain from the dustbinders?
Answer: There is some effect when the dustbinders mix with dust.
Remark: In Germany dustbinders are used only in dry weather and once a week the roads are sweeped to remove the salt and dust.

Session 5

Catalytic coatings TiO_2

TiO2 trials by IPL (in laboratory, Proeftuin) incl. International research
by *Dr. Jan Duyzer,* TNO

Most effective coatings were used in the experiment, yet there was little success. This might have to do with:
- UV intensity (at night zero);
- Low temperature;
- Moist panes after rain and dew;
- Turbulence differs from model calculations.

Conclusions
- TiO2 coatings can be quite efficient in removing NO from (test)atmosphere
- Model calculations show that the effect in the field could be significant
- Field experiments show that:
  - The uptake of NOx is much lower then expected;
  - There is no clear explanation available at this stage;
  - Little effect on NO2 concentrations near roads.

Question: Did you use different types of coating?
Answer: We had only contact with one producer of TiO2. But it has to do with the binder, you have to bind Ti02 and that part of the coating didn't work.

Question: Could the system be applied in tunnels with artificial UV-light?
Answer: A good suggestion, although the newer coatings are less dependent on UV-radiation.

Question: Did you take into account research from abroad, e.g. Italy or Japan?
Answer: Yes we tried to find the results but there was very little to be found in literature about this.

Question: Rainwater is not good for the conversion but on the other hand you need it. This seems like a contradiction.
Answer: It is especially moist that is blocking the molecules.

TiO_2 trials in England
by *Dr. Ian McCrae,* TRL

This session is about a highways Agency trial of a NOxer© barrier, on the M60 near Manchester.

Summary of the results:

- There is an inconclusive impact on NO_2 concentrations;
  - Some impact on concentrations at the barrier face
  - Insignificant impacts at greater distances from the barrier
- Results broadly agree with the conclusions reached by IPL;
- A number of issues remain unclear;
- Results based on the full period datasets show small changes in NO_2;
- Data mining techniques were used to filter data based upon optimum conditions;
- Under optimum conditions, NO_2 concentrations are reduced by ~ 18% at the barrier face;
- These conditions take place less than 1% of the time, so are unlikely to have any impact on annual average;
- Manchester (or possibly the UK) is not a good location for TiO_2 - annual rainfall is 807mm, 140 rain days/yr, but high humidity.

Question: Did you measure local turbulence? Because at some point there are trees right behind the wall.
Answer: This is a fair point, however more turbulence is expected from the passing vehicles.

Question: Was the health effect of the use of TiO_2 taken into account? TiO_2 is dangerous matter, with large health risks
Answer: TiO_2 is widely used in food industry so there is no reason to worry about that, but I will inform my colleagues about this.

Session 6

Optimized noise barriers

Barriers Proeftuin (test site Putten, the Netherlands): overview activities, measurements, analysis and results
by *Mr. Jan Hooghwerff,* M+P

Question 1 of this test was: do (noise) barriers have a significant impact on the dilution of airborne pollutants?
Answer:
- both for NO_x and PM_{10} significant effects were found;
- the barrier height is an important factor for the barrier effect.

Question 2 was: can barriers be optimized for this purpose?

Answer: none of the innovative barriers scored significantly better than the 'reference barrier'.

Question: Due to air flow all the different matters are mixed.
Answer: Short behind the barriers (about 10 – 20 m from the road) there is NOx and PM10 measured. Barriers give the best effects close to the road.

Data-analysis
by *Dr. Joost Wesseling ,* National Institute for Public Health and the Environment – RIVM

There is an enormous amount of data gathered. From this analysis different questions are to be investigated:

- Are the effects of barriers the same for NOx and PM10?
- What is the dependence of effect on PM10 on humidity?
- Why do the "optimized barriers" perform so poorly?
- Generalise the effects of the barriers.

Question: The main question here is why optimized barriers have such little effect on air pollution. But did you look at the effect of optimized barriers on noise-control?
Answer: This was not taken into account in these studies.

Question: This was an open-area study, but would there be a difference in residential areas?
Answer: This is a good question; we should do a wind tunnel experiment.

Question: Barriers seem to have an effect in Holland, how about the other countries represented in this congress?
Answers: Noise barriers seem to be a Dutch thing. In the UK no 7 m high noise barriers will be found, in Sweden they are not widely used.

Final remarks
by *Prof. Jos Arts*, Rijkwaterstaat and University of Groningen

- IPL has yielded a vast amount of knowledge;
- Many results are ready for use: 12 final reports with English summary;
- Some topics need further research;
- IPL has ended now, but work on air quality along motorways continues.

Final remarks about the content:

- Huge research effort on air quality and roads;
- Large scale test sites (practice);
- High quality measurements and data-analysis;
- PM10 is difficult to measure;
- Measurement vs. Modelling: validation, "round robin" test;
- Lab-experiments vs. practical experiments;
- Complexity of air quality issues.

Relevance of measures studies (very global):

Canopies and air treatment	+
DTM	+/-
Vegetation	o
Road surface	+
Catalytic coatings	o
Barriers	+

Final remarks about the procedures:
- NL: derogation EU standards - NSL operational
- IPL: extra measures with limited effect ('end of pipe')
- Therefore, focus on source measures and cooperation between governments

⇒ 'IPL paradox'

Final remarks about the process:
- Large scale experiments focusing on optimised research (time, location and stable environment, highly qualified specialists involved);
- Intense and positive cooperation (Dutch and international);
- Many stakeholders involved (partnerships);
- (Large scale) experiments have been carried out for all work streams;
- Dissemination of results, follow-up?

Discussion

Question: This is a unique situation, everybody from the field being together. How, where and when do we continue?
Answer: This is a matter of everybody's interest. ILP will continue for another one or two years in a much smaller organisation.

Question: In IPL we mainly focussed on PM10 and NOx. How about the other pollutants?
Answer: Of course there is much more, but we had to make a selection.

Question: Why wasn't black carbon measured?
Answers: This is legislation driven, the government is focussed on PM10 mainly.

Final speech
by Mr. René Vrugt, board member of Rijkwaterstaat

Sharing the result is of main importance, Rijkswaterstaat has taken its responsibility by organizing this conferential. Rijkswaterstaat will stay active in this area and invites all parties to participate and to keep sharing information.