Eksponering og helse ved legging av lavtemperaturasfalt

Anniken Sandvik
PhD-stipendiat

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Forsker

Et STAMI-prosjekt med bidrag fra Vei og jernbane EBA,
Regionale verneombud i bygge- og anleggsbransjen,
Lungeavdelingen/arbeidsmedisinsk seksjon OUS

Bakgrunn

- STAMI gjennomførte i asfaltsesongen 2011 en undersøkelse av kjemisk arbeidsmiljø ved utlegging av VA og LTA.
- Man fant at legging av lavtemperaturasfalt gav lavere luftbåren forurensning
- Det er fortsatt en diskusjon om eksponering ved asfaltarbeid kan gi negative helsekonsekvenser som redusert lungefunksjon og systemisk inflammasjon.
- STAMI ville følge opp interessen fra bransjen og generere mer kunnskap slike mulige sammenhenger.

Kartlegging av kjemisk arbeidsmiljø og mekanisk belastning ved utlegging av varmasfalt og lavtemperaturasfalt

Forfattere: Raymond Olsen, Hanne Line Daae, Kristin Halgard, Merete Hersson, Syvert Thorud, Rune A. Madsen, Stein Knardahl og Dag G. Ellingsen

Prosjektleder: Raymond Olsen

Dato: 16.08.2012

Nr. 3 Årgang 13

ISSN nr. 1502-0932

Statens arbeidsmiljøinstitutt

Kartlegging av kjemisk arbeidsmiljø og mekanisk belastning ved utlegging av varmasfalt og lavtemperaturasfalt – Oppfølgingsforsøk 2013

Forfattere: Raymond Olsen, Hanne Line Daae, Kristin Halgard, Grete A. Friisk, Rune A. Madsen, Stein Knardahl og Dag G. Ellingsen

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Dato: 27.11.2013

Nr. 9 Årgang 14

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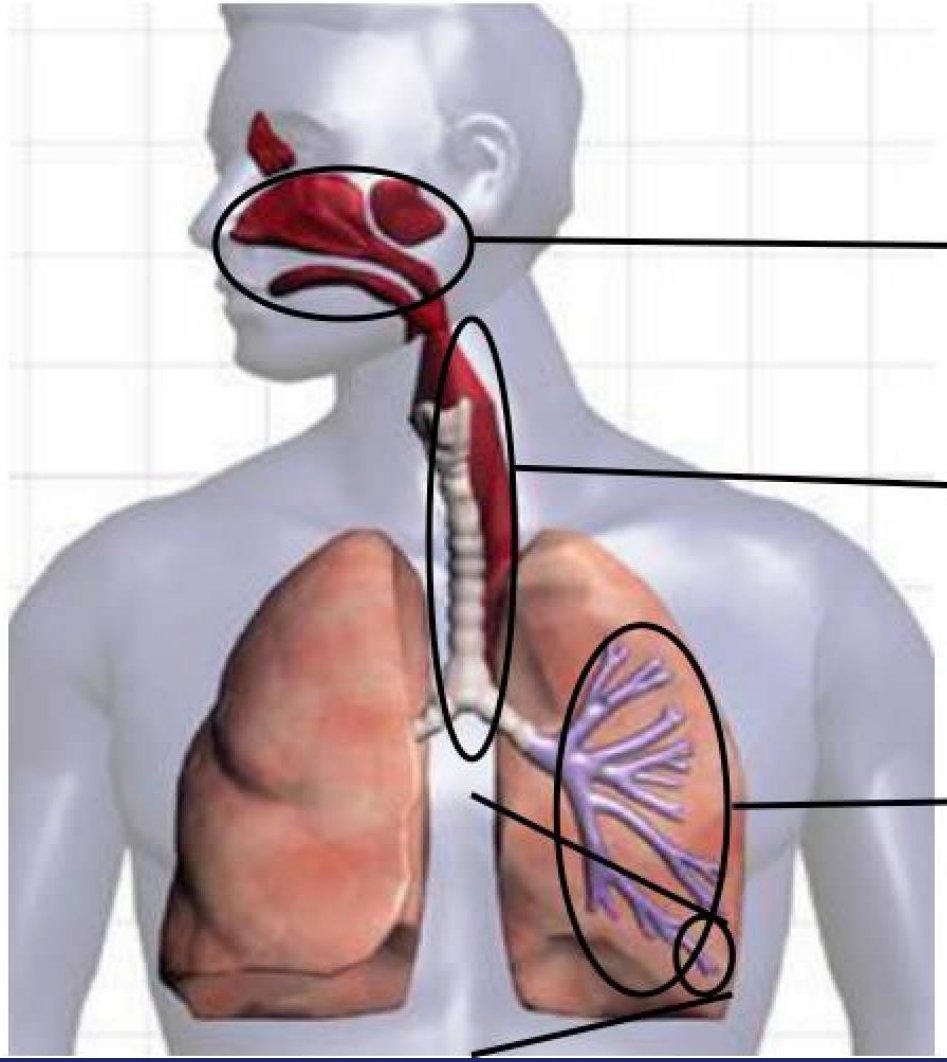
Statens arbeidsmiljøinstitutt

Kjemiske eksponeringer

- Resultatene viste en gjennomsnittlig statistisk signifikant reduksjon i asfaltrøyk på 58-67 % avhengig av målemetode ved en gjennomsnittlig reduksjon i asfalttemperaturen på 29 °C. For aminer ble det ikke funnet en statistisk signifikant endring ved overgang fra VA til LTA.

Totalstøv og respirabelt støv



Types of dust

Inhalable dust

Gets into the mouth and nose

Thoracic dust

Reaches the upper respiratory area

Respirable dust

Reaches the finest parts of the lungs (alveola)

Ergonomi

- Det ble ikke funnet noen signifikant forskjell i hjertefrekvens eller i belastning målt med kraftsensor i asfaltrake ved håndlegging av varmasfalt og lavtemperaturasfalt.

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Original Article

Original Article

Occupational Exposure during Asphalt Paving—Comparison of Hot and Warm Mix Asphalt in Field Experiments

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Abstract

Objectives: Several studies have demonstrated an increased risk of adverse health effects, including reduced lung function and lung cancer among asphalt pavers, which has been related to occupational exposure to contaminants during asphalt paving. Consequently, occupational exposure among asphalt pavers must be reduced. The aim of this study was to compare the impact of hot mix asphalt (HMA) and warm mix asphalt (WMA) paving on occupational exposure levels during road paving in field experiments. Asphalt temperatures when paving with WMA are usually lower than when paving with HMA due to differences in the asphalt's composition and method of application.
Methods: On 11 different road sections, one lane was paved with WMA and one with HMA during the same work shift under approximately identical weather conditions. The weather conditions and asphalt surface temperature were monitored during paving. Fifty-seven samples of fumes and vapor, organic and elemental carbon, amines, and respirable, thoracic, and inhalable particulate matter (PM) fractions were collected by stationary sampling. In addition, 30 samples of fumes and vapor were collected by personal sampling
Results: Compared to paving with HMA, paving with WMA significantly ($P < 0.05$; paired Student's *t*-test) reduced the geometric mean (GM) air concentration of asphalt vapor (0.04 versus 0.08 p.p.m.), organic carbon (OC; 0.09 versus 0.18 mg m^{-3}), and respirable PM (0.12 versus 0.22 mg m^{-3}). Additionally, the air concentration of OC correlated strongly with the respirable fraction of PM (Pearson's correlation coefficient 0.83).
Conclusions: Measured airborne concentrations of respirable PM, OC, and asphalt vapor were lower when paving with WMA than with HMA. Because exposure to airborne contaminants generated during asphalt paving is believed to be responsible for the adverse health effects observed among asphalt pavers, paving with WMA rather than HMA may have health benefits.

- Nødvendig å se nærmere på kjemisk eksponering med personbårne målinger og på potensielle helseeffekter

Helseeffekter av asfaltlegging (lungefunksjon)

SHORT REPORT

Respiratory symptoms and airflow limitation in asphalt workers

B G Randem, B Ulvestad, I Burstyn, J Kongerud

Occup Environ Med 2004;**61**:367–369. doi: 10.1136/oem.2002.006114

Background: Asphalt workers are exposed to bitumen fume and vapour, and to exhaust from engines and passing traffic.
Aims: To assess the occurrence of respiratory symptoms and signs of airflow limitations in a group of asphalt workers.
Methods: All 64 asphalt workers and a reference group of 195 outdoor construction workers from the same company participated in a cross-sectional study. Spirometric tests and a questionnaire on respiratory symptoms and smoking habits were administered. Respiratory symptoms and lung function were adjusted for age and smoking.
Results: The FEV_1/FVC% ratio was significantly lower in the asphalt workers than in the referents. Symptoms of eye irritation, chest tightness, shortness of breath on exertion, chest wheezing, physician diagnosed asthma, and chronic obstructive pulmonary disease (COPD) were all significantly more prevalent among the asphalt workers.
Conclusion: In asphalt workers there is an increased risk of respiratory symptoms, lung function decline, and COPD compared to other construction workers.

In Norway, 4.5 million tons of asphalt are put down every year, exposing about 2000 asphalt workers to bitumen fumes and vapour. The fume and vapour consist of long chain hydrocarbons with very small concentrations of polycyclic aromatic hydrocarbons (PAH). In addition, the asphalt workers are exposed through inhalation to exhaust from engines and passing traffic.[1]

Enhanced mortality from respiratory diseases, and enhanced prevalence of respiratory symptoms, has been reported in asphalt workers. In 1991, Hansen[2] reported an SMR of 207 (95% CI 95 to 393) from bronchitis, asthma, and emphysema in mastic asphalt workers. In a cross-sectional study, by Norseth *et al*, complaints of a sore throat or cough were more prevalent among the asphalt workers than among the road maintenance workers.[3] Gamble *et al*[4] reported a mean symptom score of 5.4% for cough among the asphalt workers in his study of asphalt fumes and acute effects on lung function. No association was found between lung function and measured levels of bitumen fumes across a work shift.

A large study of mortality involving 29 820 European asphalt workers, completed in 2001, found that relative to construction workers, asphalt workers had an RR of 1.36 (95% CI 1.06 to 1.74) of dying from a non-malignant respiratory disease.[5]

The question whether asphalt workers are at risk of the study was to assess the occurrence of respiratory symptoms and obstructive pulmonary disease in active asphalt workers compared to other outdoor construction workers.

METHODS

Subjects

All the asphalt employees (64 male workers) of one company located close to Oslo were studied. As a reference group 195 male outdoor construction workers belonging to the same company were included in the study. Data were collected in 1999. The study was approved by the National Data Inspectorate and the Regional Medical Board of Ethics.

Exposure

Asphalt in European nomenclature consists of 4–20% of bitumen mixed with crushed stone. In road paving the bitumen content is usually 4–5%, whereas mastic asphalt contains about 8–13% of bitumen. The type of bitumen and the size of the gravel vary with the properties requested from the road surface. Filler and/or fibres may also be added in order to modify the properties of the asphalt, and aliphatic amines are used to improve binding between the bitumen and the stone material.

Depending on the type of asphalt paving, temperatures vary from 70°C (soft asphalt) to 220°C (mastic asphalt); paving temperatures around 140–150°C are common. Asphalt is produced by heating and drying the gravel and mixing the hot bitumen with it. The asphalt is transported to the paving site by trucks and emptied onto the front of the paving machine. The asphalt passes underneath the machine and is spread to the desired width and thickness by the screed. A screedman or foreman controls asphalt discharge through the screed and the rakers fix the edges of the asphalt on the road manually. Subsequently, a roller compresses the asphalt.

In 1992, asphalt workers of the studied company participated in an exposure monitoring study. Results are presented elsewhere.[7] Full-shift personal breathing zone concentrations of a variety of PAHs, organic vapour, and bitumen fume were measured. In addition, CO and NO_2 concentrations in the air were determined in the vicinity of asphalt paving equipment and for CO in personal breathing zones.

The exposure of the comparison group is described elsewhere.[8] Outdoor construction workers are exposed to dust and oil mist, but at low levels (less than one third of the Norwegian occupational exposure levels).

Assessment of respiratory health effects

Questionnaire

Original article

Scand J Work Environ Health 2007;33(2):114–121

Exposure, lung function decline and systemic inflammatory response in asphalt workers

by Bente Ulvestad, PhD,[1] Britt Grethe Randem, PhD,[2] Siri Hetland, MSc,[3] Gudmunda Sigurdardottir, RN,[1] Egil Johannessen, RN,[1] Torstein Lyberg, PhD[4]

Ulvestad B, Randem BG, Hetland S, Sigurdardottir G, Johannessen E, Lyberg T. Exposure, lung function decline and systemic inflammatory response in asphalt workers. *Scand Work Environment Health* 2007;33(2):114–121.

Objectives The aim of this study was to determine the association between exposures in asphalt work and changes in lung function, blood concentrations of interleukin-6 (IL-6), micro-C-reactive protein, and fibrinogen among asphalt workers during a work season.
Methods Blood samples from all asphalt workers (N=140) in Norway's largest road construction and maintenance company were taken in April–May 2005 and again in September–October 2005. Spirometric tests of the asphalt workers and a reference group (heavy construction workers, N=126) were carried out before the asphalt season, and the asphalt workers were tested again at the end of the season. Exposure to total dust, oil mist, polycyclic aromatic hydrocarbons, and gases was measured by personal samplers during the asphalt season.
Results The asphalt workers had a significantly a lower forced expiratory volume in 1 second (FEV_1) and forced expiratory flow rate of 50% of the forced vital capacity than the reference group at the beginning of the season. The asphalt workers were divided according to their exposure into two groups, asphalt pavers (N=81) and asphalt plant operators and truck drivers (N=54). The screedmen, a group of the asphalt pavers, had a statistically significant lower FVC and FEV_1 after one season of asphalt work than all of the other asphalt workers ($P<0.05$). The mean plasma concentration of IL-6 increased among the asphalt pavers from 1.55 pg/ml before the season to 2.67 pg/ml at the season's end ($P=0.04$, adjusted for current smoking).
Conclusions Exposure in asphalt paving may enhance the risk of lung function decline.

Key terms interleukin-6, oil mist.

Asphalt paving is used for road construction and road maintenance and is carried out all over the world. In Norway, 5 million tons of asphalt is laid every year, and about 3000 workers are involved in the production and application of various asphalt mixes. The asphalt season in Norway is short, lasting from April to October in most of the country.

Air pollution is a public health issue that constitutes a health problem for workers in the heavy construction industry and is also a problem for workers involved in asphalt paving. Air pollution may affect lung function and has also been shown to affect the immune system (1–4). Asphalt workers are exposed to bitumen fumes, oil mist and vapor, polycyclic aromatic hydrocarbons

standardized mortality ratio (SMR) of 207 [95% confidence interval (95% CI) 95–393] for bronchitis, asthma, and emphysema was reported in 1991 for mastic asphalt workers (6). The asphalt worker mortality study involving 29 820 European asphalt workers reported that, relative to construction workers, asphalt workers had a risk ratio (RR) of 1.36 (95% CI 1.06–1.74) of dying from a nonmalignant respiratory disease (7). Cross-sectional studies have shown a greater risk for respiratory symptoms among asphalt workers than for road maintenance workers (8). Adverse respiratory effects and systemic inflammatory responses in workers exposed to dusts and fumes have recently been reported for several different

OPEN ACCESS

ORIGINAL ARTICLE

Exposure, respiratory symptoms, lung function and inflammation response of road-paving asphalt workers

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ABSTRACT

Background Controversy exists as to the health effects of exposure to asphalt and crumb rubber modified (CRM) asphalt, which contains recycled rubber tyres.
Objective To assess exposures and effects on airway symptoms, lung function and inflammation biomarkers in conventional and CRM asphalt road pavers.
Methods 116 conventional asphalt workers, 51 CRM asphalt workers and 100 controls were investigated. A repeated-measures analysis included 31 workers paving with both types of asphalt. Exposure to dust, nitrosamines, benzothiazole and polycyclic aromatic hydrocarbon (PAH) was measured in worksites. Self-reported symptoms, spirometry test and blood sampling were conducted prework and postwork. Symptoms were further collected during off-season for asphalt paving.
Results Dust, PAHs and nitrosamine exposure was highly varied, without difference between conventional and CRM asphalt workers. Benzothiazole was higher in CRM asphalt workers ($p<0.001$). Higher proportions of asphalt workers than controls reported eye symptoms with onset in the current job. Decreased lung function from preworking to postworking was found in CRM asphalt workers and controls. Preworking interleukin-8 was higher in CRM asphalt workers than in the controls, followed by a decrement after 4 days of working. No differences in any studied effects were found between conventional and CRM asphalt paving.
Conclusion CRM asphalt workers are exposed to higher benzothiazole. Further studies are needed to identify the source of nitrosamines in conventional asphalt. Mild decrease in lung function in CRM asphalt workers and work-related eye symptoms in both asphalt workers were observed. However, our study did not find strong evidence for severe respiratory symptoms and inflammation response among asphalt workers.

Key messages

What is already known about this subject?
- Exposure and health effects of emissions from asphalt and crumb rubber modified (CRM) asphalt paving are not clear.

What are the new findings?
- Nitrosamines were also found in conventional asphalt, suggesting sources other than reused rubber tyres may contribute to exposure.
- Decreased lung function after 4 days of paving in CRM asphalt workers and more reports of work-related eye symptoms in both conventional and CRM asphalt workers were observed.

How might this impact on policy or clinical practice in the foreseeable future?
- Future research to identify the source of nitrosamines in asphalt paving is needed to eliminate (if possible) the source and to guide risk assessment for asphalt paving.

INTRODUCTION

Possible adverse health effects of exposure to asphalt fumes have been a subject of discussion for several years. Studies have shown that asphalt road pavers are more likely to acquire eye and upper airway symptoms,[1 2] and experience lung function decline[3–5] and mild inflammation response.[6 7] However, data on current exposure conditions for risk assessment are limited, which in turn bring difficulties in setting relevant occupational exposure limits (OELs). Recently, the Swedish Criteria Group for Occupational Standards assessed that there are insufficient data to determine the critical effects of exposure to asphalt fumes during road paving.[8]

Moreover, the health impacts of exposure to crumb rubber modified (CRM) asphalt have come to the fore of the debate with the increasing use of crumbs from reused rubber tyres mixed into asphalt. However, the emissions during paving operation on site have not been extensively investigated, with an even limited number of studies focused on potential health risks.[9–12] The National Institute for Occupational Safety and Health reported higher emissions of polycyclic aromatic hydrocarbon (PAH) and benzothiazole, a mucosal irritant, in CRM asphalt paving, together with two to three times higher prevalence of self-reported eye, nasal and throat irritation as compared with conventional asphalt workers.[9] But a review pointed out that the effects of CRM asphalt, if any, were relatively small.[11] Higher PAH and benzothiazole emissions from CRM asphalt were also found in a Swedish report[13] and were recently confirmed in an experimental setting, in addition to higher particle emissions for CRM as compared with conventional asphalt.[14]

Int Arch Occup Environ Health (2017) 90:63–71
DOI 10.1007/s00420-016-1173-z

CrossMark

ORIGINAL ARTICLE

Lung function in asphalt pavers: a longitudinal study

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Abstract

Purpose To study longitudinal changes in lung function in asphalt pavers and a reference group of road maintenance workers, and to detect possible signs of lung disease by high-resolution computed tomography (HRCT) scans.
Methods Seventy-five asphalt pavers and 71 road maintenance workers were followed up with questionnaires and measurements of lung function. Not every worker was tested every year, but most of them had four or more measurement points. The 75 asphalt pavers were also invited to have HRCT scans of the lungs at the end of the follow-up period.
Results Mean annual decline in forced vital capacity (FVC) and forced expiratory volume in 1 s (FEV_1) of the asphalt pavers was 58 and 35 ml, respectively. Adjusted for age at baseline, packyears of smoking and BMI, the asphalt pavers had a significant excess annual decline in FVC and FEV_1 compared to the references. The screedmen, the most exposed group of the asphalt pavers, showed a significantly larger decline in FVC than the other asphalt pavers ($P = 0.029$). Fine intralobular fibrosis without evident cysts was identified with HRCT in three subjects (4 %).
Conclusion We conclude that our findings may indicate an excess annual decline in FVC and FEV_1 related to exposure to asphalt fumes. The screedmen, who carry out their work behind and close to the paving machine, had the largest decline in lung function. The finding of adverse pulmonary effects in asphalt pavers calls for better technological solutions to prevent exposure.

Keywords Asphalt fumes · Oil mist · Spirometry · HRCT

Introduction

Asphalt pavers are exposed to air pollution from asphalt fumes, diesel exhaust and road dust. Such exposure may adversely affect lung function. Asphalt fumes generate from the hot asphalt mix. Petroleum hydrocarbons in the crude oil/bitumen, used as a binder in asphalt, evaporate as a gas that condenses into fine particles as it cools. The chemical composition of the aerosol varies with the type of crude oil and the type of asphalt and is dependent on temperature. The aerosol contains volatile organic compounds, polycyclic aromatic compounds and naphthalene, particles, nitrogen oxides and sulfur-containing compounds. Naphthalene is a bicyclic aromatic hydrocarbon. Asphalt fumes consist partly of oil mist. In a previous study, exposure to oil mist in asphalt paving on occasion exceeded Scandinavian occupational exposure limits (Elihn et al. 2008). Exposure to oil mist may cause pulmonary fibrosis (Skyberg et al. 1986, 1992). A fraction of the particles in

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STAMI

- Risiko for redusert lungefunksjon, øyeirritasjon, økte nivåer av betennelsesmarkører i blodet
- Indikasjoner på at asfaltlegging øker risikoen også for utvikling av astma og KOLS
- Reduksjon av eksponering derfor viktig
- Det er fortsatt en diskusjon om eksponering ved asfaltarbeid kan gi negative helsekonsekvenser som redusert lungefunksjon og systemisk inflammasjon

Målsetting for vår studie

- Kartlegge om funnene for eksponering ved HTA og LTA kan reproduseres med personbårne målinger ved daglig drift (supplement til studien fra 2011)
- Hvordan påvirker asfaltlegging lungefunksjonen til arbeiderne, og er det forskjell på LTA og HTA?
- Påvirker asfaltlegging biologiske markører for inflammasjon i blodet til arbeiderne, og er det forskjell på LTA og HTA?

Planen

- Alle asfaltleggere ved flere asfaltentreprenører ble invitert til å delta. Datainnsamling: Spirometri, blodprøver, spørreskjema.
- Som kontroller ble personer fra de samme bedriftene invitert: Personer som ikke legger asfalt, men som ellers har et arbeid som likner på arbeidet til de eksponerte.
- Gjøre personbårne eksponeringsmålinger for utleggerfører og person på screed

Hvordan gikk det

- Covid19 forsinket prosjektet
- Eksponeringsmålinger ble gjennomført jevnt gjennom prosjektet
- Helseundersøkelser startet i april 2022
- Asfaltleggere rekruttert på oppstartsmøter
- Runde 2 av helseundersøkelsene var svært krevende – vanskelig å få deltakere inn fra anlegg

Innsamlede data

- 118 asfaltarbeidere rekruttert i første runde
  95 ble retestet i andre runde (80,5%)
- 57 kontroller:
  26 vedlikeholdsarbeidere på vei (Mesta)
  31 bygningsarbeidere (Veidekke)
- 96 personlige eksponeringsmålinger innsamlet (89 til analyse)

Status

- Datainnsamlingen er avsluttet
- Analyse av eksponeringskomponenter er ferdigstilt, men statistisk analyse av data er ikke ferdig
- Lungefunksjonsdata er under analyse (PhD-student)
- Analyse av biomarkører i blod februar/mars 2024
- EBA – vei og jernbane og Regionale verneombud i bygge- og anleggsbransjen har fått en preliminær rapport
- Fortsettelse følger!

Personlige luftmålinger tatt under asfaltering med PMB asfalt

6 forskjellige prøvetakere

- Respirabelt støv
- «Totalstøv»
- PAH
- Asfaltrøyk
- P-cresol
- OC-EC (organisk og elementært karbon med NO_2)

Prosjektmedarbeidere
Hilde Notø
Kristin Helmersmo
Hanne Line Daae
Vincent Simensen
Nils Petter Skaugset

Totalstøvfilter

Foto: Hilde Notø

Bitumen partikler fra utsiden av en prøvetaker og sett gjennom mikroskop

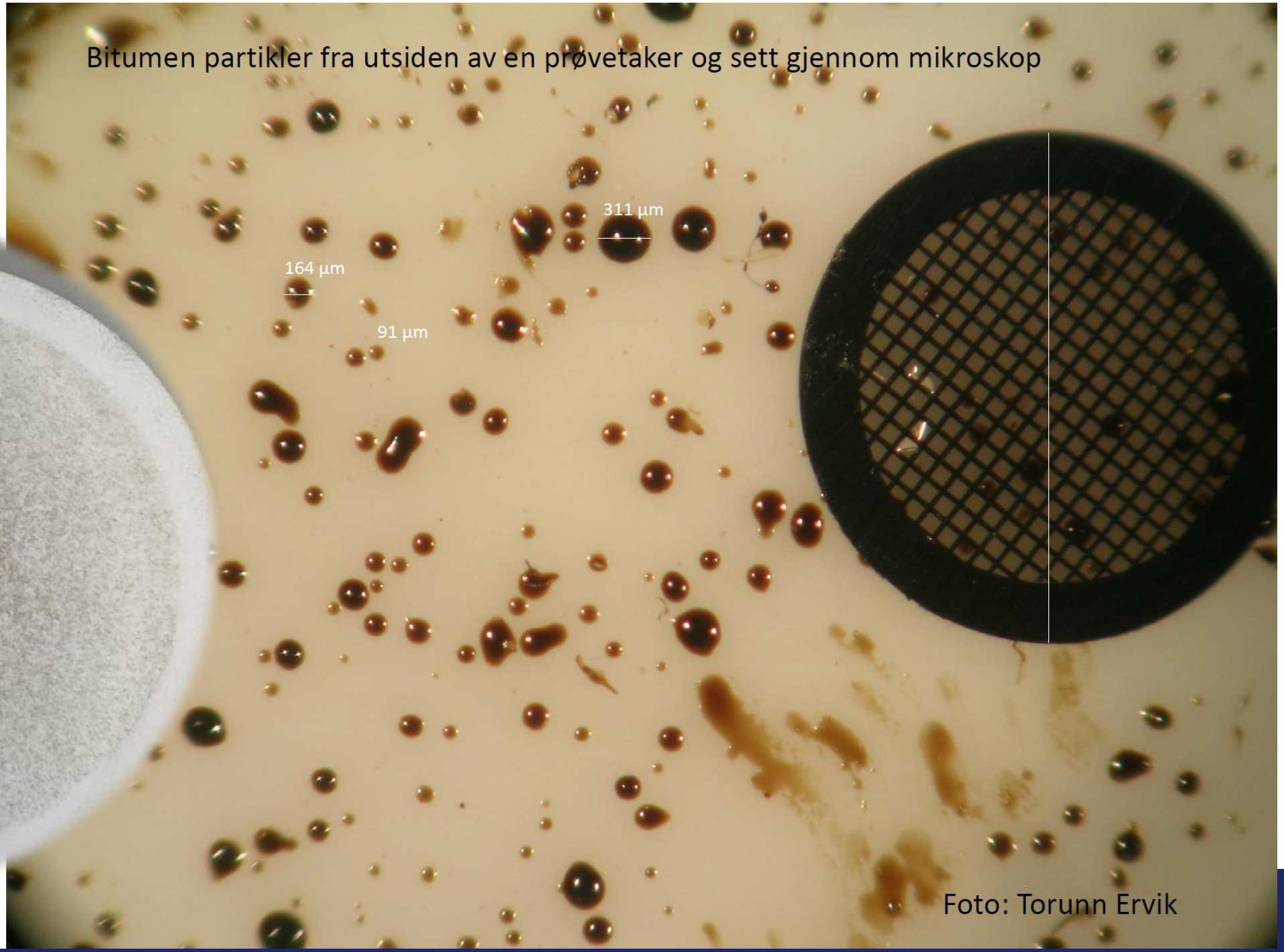

Foto: Torunn Ervik

Foreløpige resultater

Respirabelt og «Totalstøv»

- Høyere i tunnel enn utenfor
- Ser ut til å variere etter jobbtype, asfalttype og leggetemperatur (må undersøkes statistisk)
- Bioasfalt lavere enn andre typer, men har få målinger

- PAH: ikke funnet mengder over deteksjonsgrensen (bare prøver fra 2020)
- Minimal mengde EC, nesten bare OC. LiteNO2,sett litt i tunnel
- XAD-7: Få prøver med detekterbare mengder p-cresol

Sammendrag personlige eksponeringsmålinger

- Prøvetaking: 21 arbeidsskift fra mai 2020 til midten av oktober 2022.
- 6 forskjellige prøvetakere pr person
  - Respirabelt støv
  - «Totalstøv»med analyse av filter for organiske forbindelser/asfaltrøyk
  - «Totalstøv»med filter fo rbestemmelse av organisk karbon(OC), elementært karbon (EC) og NO2
  - «Totalstøv» med filter for bestemmelse av PAH (polysykliske aromatiske hydrokarboner)
  - XAD-7adsorbentrør til cresol
  - Tenax-rør for flyktige organiske forbindelser (VOC). Ikke kvantifisering.

- Nesten hundre prøver pr prøvetaker hvorav ca 89 brukes i databehandling
- 1-8 skift pr person
- Ca19, 40, 9, 13 og 8 prøver pr prøvetaker for henholdsvis utlegger, screed, formater, vals/ traktorkjøring og diverse arbeid

Tusen takk til alle deltakere fra NCC, Veidekke og PEAB!!!!

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NATIONAL INSTITUTE OF OCCUPATIONAL HEALTH