

# **Project „Study of the Health Impact of Oil Shale Sector“**

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## Summary of contents

This summary gives an overview of the study named “Health impact in oil-shale sector”. There are detailed information about the project in seven independent reports.

The results of the study on the health effects of the oil shale sector indicate that the health status of residents of Ida-Viru County is worse in many respects than elsewhere in Estonia, with environmental pollution originating from the oil shale sector being one of the reasons. However, this region is characterised by complex problems (such as other forms of industrial pollution, legacy pollution, difficult socio-economic situation, lifestyle, etc.), which also have an impact on the health of the residents.

Although the state of the environment has improved significantly in Ida-Viru County over the years, the data of Statistics Estonia show that the life expectancy of a child born in Ida-Viru County is still nearly five years shorter compared to that of a child born in Tartu or Tallinn. Also, the rates of disorders of the respiratory system diagnosed in children living in Ida-Viru County and mortality from disorders of the circulatory system are higher in Ida-Viru County than elsewhere in Estonia. On the other hand, mortality from accidents, poisonings and trauma is also significantly higher, which points to high risk behaviour among the residents of the region (Annex 1).

The study involved an analysis of pollution permits and monitoring data, followed by the modelling of pollutant levels in order to better quantify the exposure of the population to pollution across the region. Extensive clinical surveys of the respiratory tract-related ailments were conducted among more than 1000 children living in Ida-Viru and Lääne-Viru Counties and the results were compared with the data on children living in Tartu. In addition, more than 3000 adults living in Ida-Viru and Lääne-Viru Counties and Tartu were surveyed. The health complaints revealed in the surveys were associated with air pollution levels in the region. The safety of drinking water was analysed separately, to which end the exposure of the residents to contaminated drinking water was studied and, on this basis, the health risk of the population was calculated. The population’s perception of drinking water-related risks was also assessed on the basis of a survey.

The analysis of the quality of ambient air showed a clear problem in relation to industrial pollutants – formaldehyde, phenol, benzene and hydrogen sulphide, whose concentration levels have constantly exceeded the relevant pollution limits. Thanks to the toughening of environmental protection requirements and the investments in new technologies and treatment facilities, however, the number of exceedances of the levels of problematic pollution components has decreased in recent years (Annex 2).

While the analysis indicated that the emissions reported by companies over the years have mostly been lower than the maximum limits set by pollution permits, the comparison of actual measured concentrations with computational modelled concentrations suggested an underestimation of emissions and/or the number of plants emitting these pollutants in the region studied. It is recommended to check

the companies and the emissions reported by them or to validate methodologies. If reported emissions are better aligned with actual emissions, it will be possible to obtain, through modelling (in addition to the regular/random monitoring), more accurate data on any location/pollutant in Ida-Viru and Lääne-Viru Counties (Annex 2, 3).

The ways of submission of the data being collected should also be improved: compared to the reports that are currently submitted in PDF format it would be easier to process electronically submitted data. Where a company is subject to monitoring, the monitoring station should be part of the Estonian Air Quality Management System in order to ensure, first, regular checks of measurements and equipment and hence the data accuracy, and secondly, that the data can be used in various studies and analytical processes to assess the impact of the company's operations on the ambient air quality in the region. More long-term measurements of the industry-specific pollutants such as benzene, phenol and formaldehyde would also be needed. Better data would allow us to more precisely analyse the health effects of the operations of industrial companies.

This study also revealed that the residents of Ida-Viru County are concerned about the environment and their health. A survey conducted among adults showed that more than 10% of the population of Ida-Viru County consider air pollution to be unbearably disturbing (respondents had to assess the extent to which air pollution disturbs them on a 10-point scale). In addition, half of the respondents considered air pollution to be a high or very high threat to their own health and to the health of their families and loved ones (while in Lääne-Viru County and Tartu the proportion of such residents was 10-15% lower). Even though the environment of Ida-Viru County has become significantly cleaner than in the previous period, the residents' expectations of the state of the environment have also increased (Annex 4).

Of the residents of Ida-Viru County who participated in the survey, 20% had felt an unpleasant odour in the ambient air, 30% had been concerned about their health and/or thought that their quality of life was deteriorating due to air pollution, 7% had avoided being outdoors and/or opening of windows, and 12% had thought about moving elsewhere during four weeks preceding the survey. Thus, the proportion of people who are worried about their health is high. Increasing concern about disturbing odours is indicated, among other things, by the frequent complaints of residents in and around Sillamäe. Industrial pollutants are often characterised by a very low smell threshold, i.e. an unpleasant odour is felt at very low concentrations, well below the limit values. Of the respondents in Ida-Viru County, 5.8% complained about industrial noise, stating that the noise audible in their bedrooms was of a high or very high level (Annex 4).

The project also included extensive surveys involving more than 1000 school children living in Ida-Viru and Lääne-Viru Counties, where parents were asked to answer a questionnaire about their children's health, to which they replied with their children, and clinical tests of respiratory function were conducted in schools. The results were compared to the results of a similar survey conducted among children living

in Tartu County three years ago. The survey involved children in grades 3 and 4 in a total of 21 schools. It appeared that, in the last 12 months, children living in Ida-Viru County had experienced dry cough, mucous secretion and daily allergic rhinitis significantly more frequently ( $P < 0.05^1$ ) than children living in Tartu County. However, itchy skin rashes were not more frequent in children living in Ida-Viru County compared to children living in Lääne-Viru and Tartu Counties. A particularly acute problem is the prevalence of asthma in Ida-Viru County (13%), which appears to be higher than in any previous surveys conducted in the region. Based on the survey, the prevalence of asthma is significantly higher than in Tartu County, but the difference with Lääne-Viru County is not statistically significant. In Jõhvi and Ahtme schools, the prevalence of asthma as reported by parents even exceeded 20% (Annex 5).

The high (greater than 30 ppb) values of exhaled nitric oxide (FeNO, a marker of allergic inflammation) in many children constitute an even more serious problem. High FeNO values are predictors of asthma, atopy, bronchial hyperreactivity and atopic asthma. Long-term high values can, in the absence of treatment, lead to a chronic damage of the respiratory tract. The indicators of inflammation are generally low in children under treatment for asthma. The proportion of children with high FeNO values but in whom asthma has not been diagnosed was over 10% among the children surveyed in Ida-Viru County, significantly higher than in Lääne-Viru and Tartu Counties ( $p < 0.05$ ). The proportion of such children was particularly high in Kiviõli schools (15%), where asthma has been diagnosed in just 5% of children. This points directly to the need to pay more attention to the spread, diagnosis and treatment of asthma among children living in Ida-Viru County, considering that the survey involved only a part of the schools in the region and only some children in grades 3 and 4, who had been included in the random samples (Annex 5).

Next, relationships between the prevalence of asthma and the environmental pollution in Ida-Viru County were tested, using logistic regression models and previously modelled air pollution values in children's places of residence. Because there are a number of other risk factors for developing asthma, the statistical models were adjusted for other factors such as gender, age, body mass index, tobacco smoke at home, and parents' income. It appeared that children living in regions where the ambient air contained higher levels of formaldehyde had a 1.7 times greater chance ( $p < 0.05$ ) of developing asthma and had higher risk of getting symptom like "wheezing in the chest". Children living in more polluted regions also had problems with sneezing and dripping or stuffy nose even when they did not have a cold or a viral illness (Annex 5).

The scope of the project also included epidemiological surveys in adults. To this end, a questionnaire was sent to 2500 residents of Ida-Viru and Lääne-Viru Counties and to a reference group of 2750 individuals living in Tartu. In addition, information collected during a similar survey entitled "Respiratory Tract and Health III" carried out in 2011 and 2012 was considered. The database contained

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<sup>1</sup> $p < 0.05$  – statistically significant results at 95% confidence level.

the responses of a total of 3415 respondents aged 18-84 years. The analysis showed that the residents of Ida-Viru County, compared to those of Laane Viru, complained significantly more frequently about tightness of the chest (30.1%), long-term cough (29.3%), phlegm in the lungs (38%), wheezing and squeaking sounds in the chest (32.4%), heart diseases (16.3%), hypertension (34.4%), stroke (3.6%), diabetes (9.9%) and cardiac infarction or angina pectoris (7.8%). Men living in Ida-Viru County suffered significantly more frequently ( $p < 0.05$ ) from chronic obstructive pulmonary disease, wheezing and wheezing sounds in the respiratory tract and heart attacks, while asthma and rhinitis were more frequent among women. The survey also identified significant differences between ethnic groups, with non-Estonians suffering more from most of the health complaints and chronic diseases that were asked about (Annex 4).

With adults, too, relationships between the self-reported health complaints and the modelled air pollution levels were tested. It appeared that people living in regions where ambient air contained higher levels of benzene, phenol, formaldehyde or fine particles were more likely to experience shortness of breath, asthma attacks, long-term cough, phlegm in the lungs, wheezing sounds in or tightness of the chest, as well as heart attacks or angina during the past year (Annex 4).

Another analysis examined the quantities of the pollutants that the entire population of Ida-Viru County is exposed to, in order to assess the proportion of the exposure attributable to the oil-shale sector. To this end, average concentrations of pollutants in the places of residence of the population, based on the 2011 population and housing census data, were estimated through modelling. The average modelled concentrations of benzene, phenol, formaldehyde and fine particles in Ida-Viru County are 0.13, 0.58, 4.10 and 4.89  $\mu\text{g}/\text{m}^3$ , respectively, with 99, 99.1 and 96%, respectively, originating from the oil shale sector (Annex 4).

Given that, apart from the living environment, also the working environment plays a role in the development of diseases, the occurrence of symptoms and disease were compared between individuals who have and who have not worked in the oil shale sector. Those who have ever worked in the oil shale sector have significantly more frequently ( $p < 0.05$ ) reported wheezing sounds in and tightness of the chest, shortness of breath, phlegm in the lungs, wheezing sounds in the respiratory tract, hypertension, stroke, heart diseases, cardiac infarction or angina pectoris and diabetes, as well as a decline in the sense of smell in the recent past (Annex 4).

Because benzene, formaldehyde and fine particles are established carcinogens (included in group 1 according to the classification of the International Agency for Research on Cancer), a cancer incidence analysis was also carried out in Ida-Viru County. Data of the Cancer Register on a total of nine malignancies from the period 1992–2009 were used. Based on these data, cancer incidence rates in different regions were compared, based on the places of residence at the time when cancer was

diagnosed. In order to quantify the potential impact of mining, production and power plants, rural municipalities were divided into groups according to their main activities (Annex 6).

It was concluded that, among the malignancies studied, only lung cancer in men has occurred at higher rates in the oil shale municipalities of Ida-Viru County compared to the average incidence rate for Estonia. However, the difference between the incidence rates has decreased during the study period (1992–2009), which refers to the positive impact of the reduction of emission levels and/or production volumes (up to 25 million tonnes in the 1980s, 10 million tonnes in the early 2000s, and 15 million tonnes at present). During the period 1992–1997 the average number of lung cancer cases per 100,000 men was 118 per year in oil shale municipalities and 91 per year on average in Estonia, during the period 2004–2009 the numbers were 110 and 92 cases per 100,000 men per year, respectively. In the comparison of oil shale municipalities, lung cancer incidence rates have been higher in mining and production municipalities (2004–2009: 130 cases per 100,000 men per year) and lower in power plant municipalities (2004–2009: 96 cases per 100,000 men per year) (Annex 6). Because lung cancer aetiology includes several factors, some of which like tobacco smoke stronger than environmental exposures, it is difficult to assess the role of the oil-shale emissions, though it is likely that they may have played a role.

The radioactive radon gas, present in Ida-Viru County, is another important risk factor for lung cancer. Average radon levels to which the residents of different rural municipalities are exposed were determined on the basis of previous measurements. The highest levels were found in power plant municipalities, which had the lowest incidence of cancer. Even higher levels were present in mines, suggesting that the working environment also has an impact: among oil shale municipalities, the highest incidence occurred in mining municipalities during the last two periods, 1998–2003 and 2004–2009, possibly owing to the fact that many residents of production or power plant municipalities or non-oil shale municipalities of Ida-Viru County work in mines (Annex 6).

Data on the quality of drinking water were also analysed during the study. Water supplied through public water supply networks generally meets the quality requirements for drinking water in terms of both chemical and microbiological parameters, and is constantly monitored. With one exception of high levels of Benzene in drinking water in Kohtla-Järve Oru district. To relieve the possible health effects safe water is provided with water trucks and water source has been changed. The quality of drinking water obtained from private water wells (bore wells and pit wells), on the other hand, may be at risk due to pollutants of industrial source, including originating from the oil shale industry, because the majority of the wells get water from water layers that are nearer to the surface and not protected from pollution. However, microbiological pollution of private water wells is a greater threat, which is not related to the oil shale industry (Annex 7). Groundwater surveillance is well organized, but for additional measure drinking water that sources from Ordovician or Quaternary water layers should be further analysed for possible pollution from oil shale industry. Regarding water quality of private wells the main focus point

should be microbiological safety of the water and owners of these wells should be given advice if needed. The growth of existing water supply zones and creating new ones is also necessary, as water coming from public water supply zones is analysed frequently and is safe for consumption. One alternative could be state financed programs to help private well owners renovate their wells or drill new ones (when connection to existing water supply zones would be highly inefficient). It is also important to fund decontaminations of residual waste sites.

Despite the fact that drinking water generally meets legal requirements, the population is still not satisfied with its quality. Nearly half (46%) of the respondents in Ida-Viru County stated that they drink either bottled or boiled water from time to time. The proportion of such people accounted for around a quarter (26%) in Lääne-Viru County and was even lower in Tartu (22%). This suggests that we should give the population more information about the good quality of drinking water supplied through public water supply networks (Annex 4).

In summary, it appeared that people living in Ida-Viru County have more health complaints and diseases whose incidence is related, among other things, to environmental pollution. While no one doubts the necessity and importance of the oil shale sector in Ida-Viru County, the results of this study show that we need to pay more attention to the state of the environment and the health of residents in the region and to carry out even more accurate and comprehensive health surveys. Long-term improvement of the health of people living in Ida-Viru County depends on cooperation between decision-makers, scientists, local governments, businesses, health systems and local residents.

Institutions that participated in the study:

Estonian Health Board; University of Tartu Department of Public Health; Tartu University Hospital Children's Clinic Tartu; Estonian Environmental Research Centre.

As a consultant were involved representatives of World Health Organisation (WHO) Marco Martuzzi and Ivano Iavarone (Italian National Health Institute).