

# **Audit report**

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Efficiency of the organisation of environmental monitoring

Tallinn  
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## Summary

Environmental monitoring is necessary for providing information to the public and decision-makers so that they could plan their activities with due regard to environmental concerns. According to the European Environment Agency, 6–3% of all illnesses are caused by the polluted environment. Monitoring helps to identify the polluters and thereafter develop measures to reduce the pollution. Analysing of monitoring results enables to gain an overview of the environmental state, to establish links between different environmental indicators, to give judgements on larger areas by generalizing the results of individual measurements, and to predict future changes. The National Audit Office (hereinafter NAO) audited the activities of the Ministry of the Environment in organising the environmental monitoring.

Over the years, environmental monitoring has been carried out at more than 4000 monitoring sites, while more than 200 indicators have been measured. The Estonian Environment Information Centre assembles and discloses the results of environmental monitoring. In 2006, about 20 million EEK was spent on organising the environmental monitoring. In addition to state agencies, the environment is also monitored by enterprises and local governments. Whereas the local governments arrange monitoring on their own, the enterprises are given monitoring conditions by the County Environmental Departments of the Ministry of the Environment.

In order to organise monitoring in an optimal way, it is essential to consider carefully what information is necessary to assess the state of the environment, to work out measures for improving the environmental state and to evaluate the efficiency of these measures. As the users of monitoring results require different kinds of information, the results must be analysed and the data must be provided by taking into account the needs of different user groups. The lack of analysis is demonstrated by the fact that although according to the results of WHO model analysis, the pollution of ambient air with fine solid particulate matter causes up to 600 premature deaths in Estonia every year, the polluters are yet to be identified.

An overview of the environmental state has to be available to environmental officers, as well as to all citizens. For example, the floods in January 2005 would have had less severe consequences if the residential buildings could have been constructed with due regard to the information on potential rise in water level.

**In the opinion of the National Audit Office, the environmental monitoring is not well organised, as the public and decision-makers lack sufficient information on the state of the environment. The major shortcoming is that the organisation of state environmental monitoring is not based on an analysis as to which data is actually required to make decisions affecting the environment.** Thus it is not ensured that monitoring is carried out in most crucial areas and with sufficient thoroughness. Likewise, inadequate attention has been paid to analysing the optimality of the monitoring programme. Consequently, some important problems are not examined, some indicators are monitored in too many sites and too often, or in a duplicated way. As the monitoring results are subject to little analysis and difficult to access, they cannot be used to necessary extent in making environmental management decisions. Due to the shortcomings in environmental monitoring, there is no certainty that the rest of the expenditure on environmental programmes is used efficiently and that priority is given to major problems.

### Main observations

**There is no sufficient analysis as to what, where and how should be monitored.** The fact that the planning of environmental monitoring is not based on environmental problems also complicates the interpretation and use of its results. State environmental monitoring is mostly planned in the light of EU and other international commitments, while national needs have been neglected. For example, in recent years, the environmental impacts of urban sprawl, transport and several major industries have increased, but the need to adjust environmental monitoring accordingly has not been analysed. At the

same time, some international commitments (e.g. monitoring of long-range air pollution) are still not fully met.

**The state does not have a long-term plan for organising environmental monitoring.** So far, no monitoring programme has been prepared, which is required by the Environmental Monitoring Act. The Minister of the Environment approves the sub-programmes of state environmental monitoring, their budget and the persons responsible for their implementation newly every year according to applications. As environmental monitoring is not planned in longer perspective, the opportunities to organise the monitoring in a more optimal way are not taken, such as to monitor slow environmental changes at an interval of several years.

**The Environmental Register does not assemble all the necessary information.** Pursuant to the law, the purpose of the Environmental Register is to retain and process data on natural resources, natural heritage, the state of the environment and environmental factors, as well as to provide information. Currently, the environmental monitoring data is distributed between about 40 databases of various institutions. On the web-page of the Environmental Register, there are disclosed only the annual reports of environmental monitoring sub-programmes. These annual reports are very difficult to use, because the data is given in different forms and comparing the reports from different years is complicated. The most comprehensive overview of the environmental state is provided in the Environmental Reviews, which are published by the Estonian Environment Information Centre in every four years. At present, the Environment Information Centre has undertaken to improve the Environmental Register.

**The use of monitoring data collected in previous years is complicated.** Although environmental monitoring has been carried out for more than ten years, in most respects, no long-term databases have been generated. It is often difficult to use the available data gathered during the previous decade, because most of it is stored on paper or on electronic media which have become obsolete.

### **Main recommendations to the Minister of the Environment**

- To determine the monitoring need (incl. problems, areas to be monitored) based on priority environmental fields and the factors affecting them, and by doing so, to take into account the needs of the users of monitoring results and involve the specialists of respective fields. This will ensure that environmental monitoring is kept up to date even in a rapidly changing economic situation and that crucial environmental problems are addressed first.
- To prepare a long-term environmental monitoring programme by involving also the monitoring currently exercised by subordinate agencies, as well as the environmental monitoring activities of other ministries and local governments. Such an arrangement enables to decide more efficiently over the factors to be monitored in the environment, while it also raises society's confidence that problematic environmental fields are subject to data collection.
- To find out, what environmental monitoring data and in which forms do the users of monitoring information require, and to take this into consideration in planning the monitoring, and in analysing and presenting the results.
- To develop procedures for disclosing the environmental monitoring results, considering the needs of different users groups. For example, to create a two-tier database, which would provide the public with generalized data in the form of visualised maps and tables, while registered users (e.g. officials, scientists, interest groups) could also access primary data together with metadata. Careful consideration of disclosure procedures facilitates more efficient use of resources, since less time is spent on responding to enquiries.
- To initiate amendments to the Environmental Monitoring Act in order to set new deadlines for entering the data into the Environmental Register and to require the submission of all data obtained in the course of environmental monitoring (incl. the monitoring activities of enterprises and local

governments) to the Register. The inclusion of all environmental monitoring data into the Environmental Register is necessary for gaining a better overview of the state of the environment in different regions.

- In addition to state environmental monitoring, to integrate also the environmental monitoring results of other ministries, local governments and enterprises into the Environmental Register and/or refer to them in the set of links in the Register. The consolidation of the environmental monitoring results of different institutions and levels enables to improve the consideration of the environment in decision-making and facilitates the national studies not only in the field of environmental monitoring but also in other fields.

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### **The reply of the Minister of the Environment**

The Minister of the Environment finds in his letter of reply that the National Environmental Monitoring Programme established for the year 2000 is valid up to now. The NAO regards this position as unreasoned, because the activities of the Programme are planned only for 2000 and likewise, the explanatory memorandum of the Programme indicates that it is prepared for the following year (which is the year 2000). The Minister of the Environment explains in his reply that during 2007–2008, he intends to amend the Environmental Monitoring Act and specify its requirements regarding the monitoring programme.

The Minister of the Environment is planning the preparation of a long-term (2007–2009) monitoring programme, which would integrate the monitoring coordinated by the Ministry of the Environment and its subordinate agencies, as well as the monitoring carried out by other ministries.

In the opinion of the Minister of the Environment, the organisation of environmental monitoring can be improved primarily by launching the monitoring by local governments, but he finds that the Ministry has limited capacity to organise such monitoring. In NAO's opinion, the Ministry of the Environment can influence the organisation of environmental monitoring in local governments by involving the municipalities into the determination of monitoring needs in the course of preparing the long-term monitoring programme.

The Ministry of the Environment assures that the Environment Information Centre will continue to clarify the needs of environmental monitoring and has already started to improve monitoring outputs (a possibility to submit enquiries in the monitoring web, graphs, disclosure of regional results etc.) in order to improve the availability of environmental information.

Although the NAO had several meetings with the representatives of the Ministry of the Environment during the audit, the Minister provided new information in his letter of reply, according to which the NAO adjusted the final audit report in some respects.

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## Introduction

**The objective of the audit** was to assess the efficiency of the organisation of environmental monitoring.

**The institutions audited** were the Ministry of the Environment and its subordinate agency, the Estonian Environment Information Centre.

**The period audited** was the present situation, for which the data and activities from previous years were also examined if it was necessary.

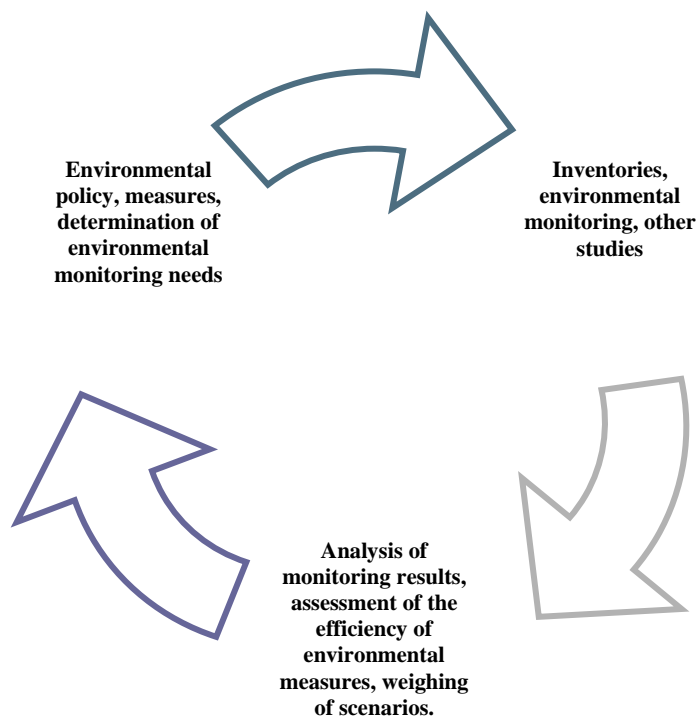
**The audit team** comprised of Ms Tuuli Rasso, Audit Manager, and Veljo Kimmel and Airi Andresson, Auditors.

The audit analysed state environmental monitoring. Main observations were made concerning the monitoring of physical and chemical parameters.

## Overview of the subject field

Environmental monitoring is used globally to assess the environmental impact of activities, the risks caused by the environment and the success of environmental policy.

**Figure 1.** The position of environmental monitoring within environmental management



Source: NAO

The most relevant legal acts regulating the organisation of environmental monitoring are the Environmental Monitoring Act and the Environmental Register Act (in regard to storing, releasing and disclosing of monitoring data). According to the law, environmental monitoring is the continuous monitoring of the state of the environment and the factors affecting it, which includes environmental observations and analyses and processing the data obtained from observations.

Pursuant to the Environmental Monitoring Act, the purposes of environmental monitoring are

- to assess and analyse the factors affecting the environment;
- to observe and assess the meteorological and hydrological factors and to predict their changes;
- to assess the state of the environment and predict the changes therein;
- to find out the state and amount of renewable natural resources;
- to identify the changes in the environment which require implementation of measures or further examination;
- to monitor long-range transboundary pollution and conduct benchmarking studies on the basis of international agreements;
- to develop and improve the system of indicators characterizing the state of the environment;
- to obtain source data for preparing programmes, local plans and development plans.

Environmental monitoring can be divided into two parts: monitoring the use of natural resources and monitoring the environmental state.

Efficient environmental monitoring enables to establish environmental risks and thereafter, to act according to them. The outcomes of environmental monitoring enable to identify and limit the causes of problems and to avoid a situation, where only consequences are aimed to be combated.

#### **Levels of environmental monitoring and its implementers**

Environmental monitoring is carried out by the state, local governments and enterprises.

Pursuant to the Environmental Monitoring Act, the state environmental monitoring is organised under the National Environmental Monitoring Programme, which is annually re-approved by the Minister of the Environment. The National Environmental Monitoring Programme comprises of the list of larger sub-programmes, the institutions carrying out the works (responsible institutions) and the budget. The law defines neither the notion of the environmental monitoring programme nor its sub-programme. The environmental monitoring programme can be interpreted through the components it must include pursuant to the law (the Environmental Register Act, Article 3, paragraph 2).

The levels implementing the state environmental monitoring programme are:

- the general coordinator,
- the Monitoring Council,
- the institutions responsible for sub-programmes and
- the persons exercising the actual monitoring.

The general coordinator of environmental monitoring is the Ministry of the Environment, which is responsible for the implementation of the monitoring programme and organizes the work of state environmental monitoring sub-programmes. The Ministry of the Environment establishes the Monitoring Council, which is tasked to advise the organisation of environmental monitoring and to supervise the implementation of the monitoring programme. The institution responsible for a sub-programme manages the work of a state environmental monitoring sub-programme. There are no restrictions regarding the potential institutions responsible for implementing the sub-programmes. The Minister of the Environment approves the sub-programme and appoints the institution responsible for it following the proposal of the Monitoring Council by entering into a contract with this institution.

The Monitoring Council consisting of six members manages the state environmental monitoring by evaluating the applications and coordinating different monitoring programmes. Everyday activities in preparing the contracts for the institutions participating in monitoring, as well as in collecting, assembling and generalising the data and reports are carried out by the Estonian Environment Information Centre under the monitoring support programme.

In the regulation of the Ministry of the Environment<sup>1</sup>, the sub-programme is defined as a part of the state environmental monitoring programme with a pre-established purpose. Basically, the sub-programme is a contract with the responsible institution, on the basis of which the person responsible for the sub-programme is obliged to conduct (or to organise the conducting of) monitoring in a given field and according to given purposes.

The monitoring sub-programme is a conditional notion not provided by the legislation, which is used for assembling the sub-programmes within the same field.

There are following sub-programmes:

- monitoring of ambient air (6 sub-programmes),
- monitoring of ground water (11 sub-programmes),
- monitoring of internal water bodies (14 sub-programmes),
- monitoring of coastal sea (5 sub-programmes),
- soil monitoring (2 sub-programmes),
- seismic monitoring (2 stations),
- forest monitoring (2 sub-programmes),
- monitoring of biodiversity and natural landscapes (26 sub-programmes),
- integrated monitoring (2 monitoring areas),
- radiation monitoring,
- support programme.

A coordinating and responsible institution is assigned to every sub-programme. Altogether, there are 14 larger institutions or enterprises participating in the state environmental monitoring, most of them represented by scientific institutions. The number of sub-programmes and their designations have much varied throughout the history of environmental monitoring.

The annual expenses of larger environmental monitoring sub-programmes are given in table 1. The table shows that monitoring costs have increased significantly over the last years. Likewise, changes have occurred with regard to the programmes (fish resources). The monitoring of fish resources was managed under an independent programme only in two years. In recent years, the data on fish resources is collected by the Fisheries Resources Department of the Ministry of the Environment, while this does not constitute a part of the environmental monitoring.

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<sup>1</sup> The regulation no.14 of the Minister of the Environment from 15 February 2000 on “The organisation of implementing the state environmental monitoring sub-programmes”

**Table 1.** Financing of environmental monitoring programmes during 1997–2006 (million EEK)

| Year | Air + radiation | Ground water | Internal water bodies | Coastal sea | Wildlife | Integrated | Other | Fish resources | In total |
|------|-----------------|--------------|-----------------------|-------------|----------|------------|-------|----------------|----------|
| 1997 | 1.43            | 0.67         | 1.22                  | 0.57        | 0.93     | 0.60       | 3.90  |                | 9.32     |
| 1998 | 1.47            | 0.70         | 1.44                  | 0.82        | 1.14     | 0.65       | 3.22  |                | 9.44     |
| 1999 | 1.47            | 0.80         | 1.04                  | 0.94        | 1.33     | 0.98       | 2.83  |                | 9.39     |
| 2000 | 1.61            | 0.50         | 1.44                  | 0.63        | 1.30     | 1.10       | 1.97  |                | 8.55     |
| 2001 | 1.56            | 0.65         | 1.64                  | 0.95        | 1.20     | 0.80       | 1.90  |                | 8.70     |
| 2002 | 1.95            | 1.06         | 2.47                  | 1.33        | 1.47     | 0.80       | 2.47  |                | 11.55    |
| 2003 | 1.89            | 1.17         | 2.65                  | 1.43        | 1.72     | 0.80       | 2.35  | 3.30           | 15.31    |
| 2004 | 2.10            | 1.31         | 2.93                  | 1.74        | 1.70     | 0.83       | 1.82  | 3.00           | 15.43    |
| 2005 | 3.20            | 1.84         | 4.27                  | 2.41        | 2.10     | 1.25       | 2.27  |                | 17.33    |
| 2006 | 4.50            | 1.65         | 5.96                  | 2.40        | 2.35     | 1.19       | 1.81  |                | 19.85    |

Sources: the decrees of the Minister of the Environment on approving the monitoring budgets, [www.seiremonitor.ee](http://www.seiremonitor.ee)

In addition to the environmental monitoring which is exercised through the monitoring programme, the subordinate agencies of the Ministry of the Environment have also carried out environmental monitoring in recent years. This monitoring is organised by the decree of the Minister of the Environment (e.g., meteo monitoring), which includes similar appendixes describing the methodology, monitoring sites and the parameters to be measured as are given in the contracts with the institutions responsible for monitoring.

Several purposes of the Environmental Monitoring Act are currently fulfilled under other programmes. For example, the assessment and analysis of the factors affecting the environment are carried out by the Estonian Environment Information Centre in the course of examining the enterprises, as such an organisation is also used internationally. Likewise, the assessment of the state of renewable natural resources and their amount is at present not directly included in monitoring sub-programmes.

Pursuant to the Environmental Monitoring Act, **the environmental monitoring of a local government** is based on municipality's environmental monitoring programme. The municipality establishes procedures for implementing the environmental monitoring programme, and for processing and storing the data collected on the basis of this programme. The procedures and conditions for the **environmental monitoring of an enterprise** are established with environmental permits. With the current audit, the NAO assessed the organisation of the state environmental monitoring, but also examined how other studies could be regulated in respect of national needs.

### Storing of monitoring data and its public use

Pursuant to the Public Information Act, the information about the state of the environment, environmental damage and dangerous environmental impacts must be disclosed. The storing of monitoring data and its public use is organised with the Environmental Register and regulated by the Environmental Register Act. The Environmental Information Centre of the Ministry of the Environment is authorized to assemble and process the monitoring results.

### Description of the audit

The audit aimed to answer the following three main questions:

- Is the need for state environmental monitoring determined? (Are proper actions taken?)
- Is the organisation of monitoring optimal (Are actions actions taken properly?)

- Are conditions created for the use of monitoring results?

The following procedures were carried out to audit the organisation of environmental monitoring:

- Interviews were conducted with specialists from the Ministry of the Environment, the Estonian Environment Information Centre, the University of Tartu and other institutions involved in monitoring;
- A focus group meeting was organized between the representatives of the Ministry of the Environment, Estonian Environment Information Centre and environmental experts in order to assess the needs of environmental monitoring;
- In collaboration with an Expert it was assessed, whether the locating of monitoring sites is justified given the case of monitoring programmes dealing with the precipitation chemistry in open fields, and whether the monitoring data is available and presented in a commonly understandable manner;
- An Internet-based questionnaire was prepared to find out what is the opinion of the County Environmental Departments in regard to the accessibility of monitoring data, and what data and in which forms do they need;
- The possibilities of the public to obtain information on environmental monitoring results were assessed;
- The contracts of monitoring sub-programmes were analysed;
- The directives and conventions relevant to environmental monitoring were analysed.

# 1. Determination of environmental monitoring needs

According to the report of the European Environment Agency, 6–13% of all illnesses (depending on state's stage of development) are caused by environmental factors.<sup>2</sup> Environmental monitoring enables to gain an overview of the state of the environment and to find links between the environmental state and environmental parameters. Hence, environmental monitoring facilitates the development of measures to reduce the pollution and the assessment of the efficiency of such measures. Efficient organisation of environmental monitoring requires long-term planning on the basis of determined monitoring needs.

## 1.1. National environmental monitoring needs are not examined with sufficient thoroughness

As the funds for measuring the environmental state and analysing the obtained data are always limited, it is necessary to establish what fields and/or problems should be monitored first. The determination of monitoring needs is also necessary for assessing the performance of environmental policies and measures. Pursuant to the Environmental Monitoring Act, one of the purposes of environmental monitoring is also to develop and improve the system of indicators characterizing the environmental state. This is performed by the Environment Information Centre of the Ministry of the Environment.

At the focus group meeting organised by the NAO, it was found that environmental monitoring is needed for meeting both national and international objectives. For example, monitoring enables

- to gain a complete picture of the state of Estonia's environment,
- to discover a state of emergency,
- to fulfil EU and other international commitments,
- to examine specific regional environmental problems,
- to develop the water policy,
- to assess the effects of environmental pollution, including its impacts on health.

For determining the monitoring needs, a system of indicators is used in many countries and fields. Such a system is developed on the basis of environmental problems, which need to be observed, and/or the state and amount of renewable natural resources, which need to be established. Indicators of pressure, state, impact and response are used. The European Environment Agency, for example, employs a monitoring system, which is developed according to environmental issues.<sup>3</sup> An environmental issue is established first, and following that, the parameters to be monitored are also determined.

In the beginning of 1990s, the needs of Estonia's environmental monitoring were assessed by several international projects, and based on their outcomes, the monitoring was started.

In 1997–1998, following the priorities of the national environmental strategy, Danish experts prepared a system of indicators for Estonia under an EU *Phare* project (Data Use and Data Management in Environmental Monitoring Programme – DADAM). The programme involved several activities with a total cost of 421 320 EUR. According to the Ministry of the Environment, this was the first attempt to develop such a system of indicators in Estonia, but the project results were supposed to be used in the

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<sup>2</sup> Accessible from [http://reports.eea.europa.eu/eea\\_report\\_2005\\_10/en](http://reports.eea.europa.eu/eea_report_2005_10/en)

<sup>3</sup> <http://themes.eea.europa.eu/indicators/>

future, as it was not possible to implement them due to a lack of funding. As the Ministry of the Environment explains, the indicators are used in publications selectively, because the system of environmental state indicators as it was developed involves also data from other areas than the environment in its narrowest sense. Based on the project outcomes, a portal of Estonia's environmental state was also established, where the data has not been updated over the last four years (see also chapter 2.1). In 2006, the Estonian Environment Information Centre began to improve the portal's technical solution and layout.

Currently, the preparation of monitoring programmes is not based on the analysis of environmental issues covering all fields and the need to assess the efficiency of environmental protection measures have not been considered. Similarly, it was claimed at the monitoring forum in 2003<sup>4</sup> that more attention has to be paid to monitoring the efficiency of environmental protection measures, but to date, the monitoring needs are not assessed in this respect. The lack of analysis of national monitoring needs was also pointed out by the specialists convened in the course of the audit, as well as by the Expert involved in the audit (see also chapter 1.3). For example, there has been no comprehensive consideration as to whether and how the following environmental issues should be monitored in Estonia:

- Although oil shale energy has the largest impact on Estonia's environment, current state environmental programme does not provide sufficient data to assess accurately the environmental impact of this field: most of the ground water testing in North-eastern Estonia fixates only the level of ground water, but its chemical composition is measured only in three sites once a year.<sup>5</sup> Likewise, no monitoring station measures the level of contamination caused by the exhaust fumes of electric power plants. In Estonia, the soil alkalination resulting from fly ashes has damaged the regeneration of peat on an area of at least 100 square kilometres. The pollutants from electric power plants are mostly precipitated in Narva-Jõesuu district, but the existing monitoring station in Narva town does not provide any information regarding the contamination caused by the power plants.
- According to the model analysis of the World Health Organization, only the air pollution with aerosols causes about 600 premature deaths in Estonia every year<sup>6</sup>. According to studies, the high level of ambient air pollution in North-European cities is mostly caused by weather conditions, transport and household heating<sup>7</sup>. Estonia is located in a region of high cyclonic activity and consequent winds, while the dispersal of pollution is hindered only in the hinterland, for example, there are up to 90 windless days per annum in South-East Estonia, but only 10–20 such days in coastal areas. The dispersal of aerosol contamination is especially hindered in the towns situated in valleys (Tartu, Viljandi), where the risk of high pollution levels is thereby bigger.<sup>8</sup> As the existing stations that monitor air quality are located in the coastal zone, where the high concentration of pollutants occurs only rarely during windless periods, there is actually no comprehensive overview available on air quality. Such locating of monitoring stations is also not in accordance with the main requirements of directives, pursuant to which the monitoring has to be carried out specifically in the places of high air pollution.<sup>9</sup>

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<sup>4</sup> The forum „Monitoring problems, processes and consequences“ held in Tartu on 26<sup>th</sup> March 2003

<sup>5</sup> The study of the Stockholm Environment Institutes's Tallinn Centre, 2006. A report to the Environmental Investments Centre on the methodology of calculating the external costs of Estonia's energy economy.

<sup>6</sup> Health risks of particulate matter from long-range transboundary air pollution. World Health Organization 2006

<sup>7</sup> Kukkonen, J., Sokhi, R. S., Slørdal, L. H., Finardi, S., Fay B., Mill'an M., Salvador, R., Palau J.L., Rasmussen A., Schayes G., Berge, E. 2004 Analysis and evaluation of European air pollution episodes, Section 6 of the COST 715 Final Report Meteorology Applied to Urban Air Pollution Problems – <http://www2.dmu.dk/AtmosphericEnvironment/cost/FinalReports715.htm>

<sup>8</sup> Kull, A. 1996. Estonian Wind Atlas, Masters dissertation in the University of Tartu.

<sup>9</sup> The directive of the EU Council from 27 September 1996 on ambient air quality assessment and management, 96/62/EC; O.J.L 296, 21 November 1996

- The economic development that has taken place during the last decade, especially in recent years, has incurred major changes and several processes affecting the environment crucially, such as urban sprawl and increased use of cars. Said processes are also regarded as main environmental problems in the Environmental Strategy up to 2030.

In determining the national monitoring needs, the needs of the users of monitoring results shall be analysed as well. The users may involve line ministries, the staff of municipalities, as well as citizens. The meeting of focus group revealed that the user's needs are yet to be analysed (see also chapter 2.2).

The report of the European Environment Agency<sup>10</sup> emphasises, among other needs, the need to monitor the environment in order to cope with the health problems caused by environmental pollution.<sup>11</sup> Likewise, pursuant to the Environmental Strategy up to 2030<sup>12</sup>, the existing monitoring system, as well as national monitoring plans need to be adjusted with due regard to health risks.

The purpose of environmental monitoring as set by the Environmental Monitoring Act is to obtain primary data for the preparation of programmes, local plans and development plans. It has not yet been analysed, whether the current monitoring is sufficient for producing this data. The Department of Development that was established in the beginning of 2007 in the Ministry of the Environment is tasked to develop the environmental monitoring according to its statutes.

In planning the national environmental monitoring, the objectives of environmental plans as well as other development plans, programmes and legal acts can be followed, but this has been done only partly. An analysis of relevant international legal acts provided by the Ministry of the Environment revealed that most of this legislation regulates the volume of pollutants, which industries are permitted to release into the environment. Only few acts constitute the indicators characterizing the environmental state, which need to be measured in the course of environmental monitoring.

According to the explanations of the Ministry of the Environment, the commitments to environmental monitoring are largely imposed by international agreements and EU directives, which determine to great extent what is to be monitored. Concrete monitoring sites, and the methods and intervals of measurements are established by every state after analysing the local situation.

In relation to joining the European Union, it was assessed in Estonia whether the monitoring carried out in every field conforms to the requirements. For example, the implementation of the requirements of the Water Framework Directive was assessed in order to regulate the sites and parameters of measuring accordingly. Following the results of the analysis, the measuring programmes of several monitoring sub-programmes will be adjusted in 2007.

The audit revealed that at present, not all international monitoring requirements are fully met in Estonia. Pursuant to the Convention on Long-range Transboundary Air Pollution, the pollutants must be measured also in case of aerosols and gases in the air, but in Estonia, only single parameters are measured (see table 2). Likewise, problems have been encountered in meeting the requirements of EU directives, for example, hydrocarbons, the prerequisites for ozone, cannot be measured in the air, as well as other dangerous substances in the whole environment.

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<sup>10</sup> Accessible from [http://reports.eea.europa.eu/eea\\_report\\_2005\\_10/en](http://reports.eea.europa.eu/eea_report_2005_10/en)

<sup>11</sup> European Environmental and Health Strategy – <http://ec.europa.eu/environment/health/strategy.htm>

<sup>12</sup> The project of the Estonian Environmental Strategy up to 2030 in the eJustice system.

**Table 2.** The basic measuring programme established under the EMEP measuring programme of the Convention on Long-range Transboundary Air Pollution for the years 2004–2009 and the parameters to be examined. The parameters in italics are not measured in Estonia.

| Problem / media                 | Precipitation  | Aerosols   | Gases <sup>1</sup>   |
|---------------------------------|--|--|--|
| Acid rains                      | SO <sub>4</sub> , NO <sub>3</sub> , NH <sub>4</sub> , pH, Na, K, Ca, Mg, Cl, electrical conductivity | SO <sub>4</sub> , ( <i>NO<sub>3</sub>, HNO<sub>3</sub>, NH<sub>4</sub>, NH<sub>3</sub>, Na, K, Ca, Mg</i> )                    | SO <sub>2</sub> , NO <sub>2</sub> , ( <i>HNO<sub>3</sub>, NH<sub>4</sub>, NH<sub>3</sub></i> ) |
| Eutrophication                  | NO <sub>3</sub> , NH <sub>4</sub>  | ( <i>NO<sub>3</sub>, HNO<sub>3</sub>, NH<sub>4</sub>, NH<sub>3</sub></i> )   | NO <sub>2</sub> , ( <i>HNO<sub>3</sub>, NH<sub>4</sub>, NH<sub>3</sub></i> )                   |
| High concentrations of ozone    |  |  | O <sub>3</sub> , NO <sub>2</sub>   |
| Heavy metals                    | 1. priority Cd, Pb<br>2. priority Cu, Zn, ( <i>As, Cr, Ni</i> )                                      |  |  |
| High concentrations of aerosols |  | PM <sub>10</sub> , SO <sub>4</sub> , ( <i>NO<sub>3</sub>, HNO<sub>3</sub>, NH<sub>4</sub>, NH<sub>3</sub>, Na, K, Ca, Mg</i> ) |  |

<sup>1</sup>In Estonia, gases are measured with automatic gauges in every hour. It is required to measure the daily averages. This incurs ca 200 000 EEK additional costs for purchasing the equipment and ca 30 000 EEK for carrying out the measurements per the measured parameter.

Sources: The Convention on Long-range Transboundary Air Pollution, NAO's analysis.

Thus, the planning of environmental monitoring has been primarily based on international commitments, not on the analysis of Estonia's environmental problems. Hence, several crucial monitoring fields are not covered with monitoring sub-programmes and the changes occurring in the environment and their causes could be found out too late. In 1998, a system of monitoring indicators which followed the priorities of national environmental policy was prepared in Estonia, but this system was neither implemented nor further developed.

## 1.2. Environmental monitoring is not subject to long-term planning

Pursuant to the Environmental Monitoring Act, the National Environmental Monitoring Programme must contain the designations of its sub-programmes, descriptions of planned works, information on the institutions responsible for implementing the sub-programmes and the funds allocated for the implementation. The law does not indicate, for how long period of time the programme must be prepared, but according to the Environmental Monitoring Act, as well as internationally accepted principles, one of the purposes of monitoring is to collect long-term data on the environmental state and issues. In addition to the determination of monitoring needs, collecting of such data requires the analysis of monitoring activities and results, and long-term planning of resources.

At present, the monitoring is mostly planned for one year to come. The Minister of the Environment approves every year the budget of the state environmental monitoring, which includes the list of sub-programmes and their implementers, but not the descriptions of planned works. More detailed descriptions of monitoring activities and sites are stated in the contracts, which are newly signed every year. Exceptions hold for the year 2000, when the list of monitoring sub-programmes and its implementers was supplemented by an explanatory memorandum titled „Estonian National Environmental Monitoring Programme“. By sub-programmes, this document provided lists of planned outcomes and strategic changes. However, even this document planned monitoring activities for one year only. After that, no descriptions of annual activities have been prepared with such thoroughness.

In recent years, public procurements have been also introduced in order to purchase monitoring services for 3–4 years (e.g. monitoring of ground water and the eutrophication of water bodies), but the measuring programmes under these procurements are still annually re-approved. According to the Monitoring Council, the content of the measuring programmes is usually not particularly altered, but at the same time, no long-term monitoring programme has been approved either.

Planning of monitoring for one year only does not conform to the principles of EU and other international conventions relevant to monitoring, pursuant to which in most fields (ambient air, ground and surface water), the environmental changes can be accurately assessed only on the basis of monitoring results of several years.<sup>13</sup> If there is no long-term monitoring programme, then collecting of long-term data is not guaranteed.

Regarding some fields, long-term monitoring data can be also collected in ways in which the monitoring is carried out after longer periods of time (e.g. once in every 3 or 5 years). In case of several international programmes, extensive measurements are carried out only after a certain number of years have passed. Due to the short-term planning in Estonia, the monitoring is not carried out at an interval of several years.

The Monitoring Council claims that there is no long-term monitoring programme, because the international requirements are changed and in approving a long-term programme, the new requirements cannot be taken into account. In NAO's opinion, the approval of the monitoring programme with overall directions and priorities does not exclude the possibility of additional monitoring in fields, where it turns out to be necessary.

Pursuant to the Environmental Monitoring Act, one of the purposes of environmental monitoring is to identify the environmental changes, which require implementation of measures or further examination. For example, a requirement to monitor dangerous substances in the environment has been recently added to monitoring. As it was not required to measure the dangerous substances before the relevant directive was enforced, there is no respective data available about Estonia.

In preparing a long-term monitoring programme, the economical changes that entail new locations for the sources of pollution and new levels of emissions, as well as additional international requirements have to be taken into account. Monitoring needs can also change because of developments in the environmental sciences, as new environmental problems and the compounds causing them emerge.

Due to the lack of a long-term monitoring programme, the parameters to be monitored are newly discussed every year with the institutions responsible for the implementation, which is why the signing of monitoring contracts is delayed<sup>14</sup>. According to the implementers, this results in additional costs for them<sup>15</sup>. As most of the monitoring activities are carried out throughout the year, the institutions responsible for the sub-programmes have to find the necessary funds for fulfilling state's duties before they are actually contracted. The members of the Monitoring Council do not regard such a state of affairs as a hindrance, because most of the implementers are scientific institutions with budgets secured elsewhere for their main activities, which would not therefore suffer. In NAO's opinion, the current organisation does not enable to change the organisation of monitoring in the case the sub-programme is adjusted in the beginning of the year, and given the absence of contracts, the continuity of previous monitoring activities is not ensured either.

Thus, regardless of the ten years of monitoring activities, no long-term monitoring programme has been prepared, which would include the lists of objectives, works, and the monitored parameters. Such an organisation does not ensure that long-term data is collected and does not contribute to monitoring at longer intervals.

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<sup>13</sup> For example, in order to assess adequately the ambient air quality over the last 5 years, representative measuring results have to be available for at least 3 years. The directive of the EU Council from 27 September 1996 on ambient air quality assessment and management, 96/62/EC; O.J.L 296, 21 November 1996

<sup>14</sup> Discussions in the Monitoring Council on 24 May 2006, 5 and 28 September 2006

<sup>15</sup> Interview in the Estonian Environmental Research Centre

### 1.3. The locations of monitoring sites and the monitoring methodology are not always optimal

As there are many monitoring fields and monitored parameters, the most optimal way to obtain the environmental information has to be found in order to reduce the costs. Collecting of monitoring data can be improved if the selection of monitored issues, frequencies of measurements, locations of monitoring sites, monitoring methods and the monitoring exercised at different levels (state, local governments, enterprises) are carefully considered. For example, in the case of more frequent measurements within air monitoring, the number of monitoring sites could be reduced, as the frequency of monitoring and the distance between monitoring stations are correlated.<sup>16</sup>

For preparing a more optimal monitoring programme, the monitoring needs and its detailed objectives have to be determined. Depending on the monitoring objective (e.g. compliance to norms, identifying sources of pollution, assessing the efficiency of environmental programmes), it is possible to choose different measuring programmes: for example, long-term trends in air quality can be found out with cheap passive methods, whereas understanding of chemical reactions in the environment requires precision measurements at short intervals. The latter are very expensive and therefore, it is recommended to carry out measuring campaigns instead of constant monitoring.<sup>17</sup> Decision-making over the amount and content of different monitoring sub-programmes should be based on optimality analysis, which should include also other possibilities to gain information.

Currently, the state monitoring sub-programmes are developed following the applications, and neither the applicant nor the evaluator assesses, whether the same data could be obtained in some other ways, for example, by using indirect methods and/or scientific studies and/or another monitoring sub-programme. Collecting of data is rather planned with a purpose to satisfy the information needs of a scientific study. The use of obtained data for environmental management purposes is hindered, because it has not been collectively discussed, what a change in one or another parameter or index actually means or could mean.

#### **In approving the monitoring programme, the optimality of monitoring sites and frequencies is not analysed**

First analyses for assessing the optimality were made more than 15 years ago. For instance, in 1990, the scientists from Tartu prepared a monitoring programme for studying the eutrophy in Peipsi lake. The analysis of results revealed that ten characteristic testing sites out of several tens of testing sites provided data, which could be extrapolated to the whole area.<sup>18</sup> The monitoring sites established by this analysis are still in use in state environmental monitoring. However, due to the economic development and changes in pollution load, the Peipsi lake's monitoring network needs to be re-examined. Monitoring networks can be similarly optimized in other fields by analysing the factors affecting the environment and major polluters. For example, in the case of soil monitoring it has been found that certain types of soil are monitored too much and certain types too little.<sup>19</sup>

The Expert involved into NAO's audit assessed the monitoring network for precipitation chemistry and claimed that this could be improved. For example,

- Pursuant to the directives on air quality, the area of the representative sites of **air monitoring** background stations is about 10 000 square kilometres and therefore, the data from the 3 background stations in Estonia covers almost the whole country. Following the international

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<sup>16</sup> Sivertsen, B. 1997. Air Quality Monitoring and Applications, Kjeller NILU TR Report 11/97

<sup>17</sup> Bo R. Larsen. Summary of the Expert Meeting/Workshop. – Measurement of Ozone Precursor Volatile Organic Compounds (VOCs). Proceedings of The International Expert meeting 2003 Ispra, 13–30

<sup>18</sup> Möls, T., Saan, T., Lindpere, A., Starast, H. Monitoring eutrophy in Peipsi, The Institute of Zoology and Botany of the Estonian Academy of Sciences, Tartu 1990

<sup>19</sup> Roose, A. 2005. Optimisation of environmental monitoring network by integrated modelling strategy with geographic information system - an Estonian case, *Dissertationes geographicae Universitatis Tartuensis*, 22

guidelines on integrated monitoring,<sup>20</sup> it is necessary to carry out additional air chemistry (including precipitation) studies, if no suitable station is available within a radius of 50 kilometres. For instance, at the distance of 15 kilometres from the international EMEP observation station in Lahemaa, there are currently at least 2 forest monitoring stations, where in addition to the measurements of the precipitation collected from crowns and stems of trees, the rainfall in open fields is also measured.

- In 2004, there were altogether 23 monitoring points under 3 sub-programmes for **monitoring the precipitation chemistry** in open fields, while heavy metals were also measured in all of them. In Finland, which is a significantly larger country than Estonia, there are only 14 sites for monitoring the precipitation chemistry, whereas heavy metals are measured only at 8 sites. In Denmark, a country comparable to Estonia by its size and climate, the rainfall in open fields is measured only in seven places and heavy metals only in one of them. According to available monitoring results, the quality of Estonia's air is good, which is why it is difficult to justify the establishment of a monitoring network that is significantly more dense than in Denmark. In the opinion of the Expert, a reasonable number of stations monitoring the precipitation chemistry ranges from 6 to 9 pursuant to the established monitoring objectives, whereas 3 of them should be managed at the expense of the polluters (Kunda, Narva-Jõesuu, Harku).
- In several monitoring programmes<sup>21</sup> (e.g. in measuring heavy metals under **the monitoring of precipitation chemistry**), month by month, measurements are carried out, which indicate that the concentration of pollutants remains under the detection limit. The presence of such measurements demonstrates that monitoring results are not sufficiently analysed, as the density of monitoring network and/or the monitoring frequency should be minimized when concentrations are small. Likewise, due to the lack of monitoring results with numerical values, it is not possible to provide information on previous changes and consequently, to predict future changes.

The locating of monitoring stations established under several international programmes does not enable to discover the changes in the environment and their causes. For example,

- In **integrated monitoring** for assessing the negative impacts of air pollution, 2 out of 50 stations active in Europe are located in Estonia – at Saarejärve and Vilsandi. According to these stations, the level of air pollution is low and hence, it is difficult to assess comprehensively its negative impact on ecosystems. Other integrated monitoring stations in Europe monitor long-term problems of air pollution, e.g. acid rainfall. As the pollution level in Estonia's background areas is substantially lower than in Europe, the local impacts of air pollution could be examined by monitoring major industries/polluters or with scientific studies. Under scientific studies, the turnover of substances has been more closely studied, for example, at Porijõe near Tartu from 1984 onwards<sup>22</sup>, i.e. significantly longer than under integrated monitoring. At European level, the integrated monitoring stations in Estonia serve their purposes as a source for benchmarking with background areas, but the possibilities to use data at more detailed level, in respect of Estonia's interests, are limited. Therefore, the scientific institutions have established their own long-term monitoring areas focusing on studies of turnover of substances. The data of the state integrated monitoring is little used in scientific studies because it is difficult to access (see also chapter 2.1).<sup>23</sup>

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<sup>20</sup> Manual for Integrated Monitoring, Helsinki 1998

<sup>21</sup> Heavy metals in precipitation chemistry (Appendix 5), Tiina Nõges 'Monitoring major lakes', presented at the forum „Monitoring problems, processes and consequences“

<sup>22</sup> Mander, Ü., Kull, A. (1997). Variation of Runoff and Nutrient Fluxes in an Agricultural Watershed: Influence of Land Use Changes and Climatic Fluctuations. Ecosystems and Sustainable Development. Usó, J. L., Brebbia, C.A., Power, H. (Eds.). Advances in Ecological Sciences. Vol. 1. WIT Press, Southampton Boston, pp. 183-192

Järvet, A., Mander, Ü., Kull, A. and Kuusemets, V. 2002. Nutrient runoff change in a rural catchment in South Estonia. Archive für Hydrobiologie, 13:3-4, 305-319

<sup>23</sup> In international scientific literature, there are remarkably less articles published on the basis of the data obtained from integrated monitoring areas than on the basis of the data from scientific institutions' own monitoring areas.

- Likewise, the monitoring programme for implementing the Convention on Long-range Transboundary Air Pollution does not conform to international requirements<sup>24</sup>. As it is complicated to implement the programme to full extent in the current two points – Vilsandi and Lahemaa – due to financial reasons, it should be considered to implement the programme only in one point, and additionally, to monitor issues which are important to local monitoring in another.
- Adjustments are needed in the monitoring programme also in respect of the high concentration of fine particles in air. So far, it is yet to be discovered, what causes the significant increase in the level of pollution with fine solid particles every spring (see also chapter 2.3). The modelling of aerosol pollution in Europe has revealed that the concentration of fine particles in air is significantly impacted by large plantless areas and dry deposition.<sup>25</sup> As the concentration of particulate matter in air is correlated with both its generation and precipitation, it is necessary to know exactly all sources of its generation, as well as the rate of precipitation. The surveys of enterprises do not provide any data on the sources of fine particles in Estonia. Likewise, it is currently not possible to assess accurately the rate of pollutants' precipitation, as there is no data available on the constituents of aerosol (see table 2).

**In approving the monitoring programme, the optimality of monitoring methodology is not analysed.**

In addition to analysing the density of monitoring network and the monitoring frequency, monitoring can be more optimally organized also by choosing its methods. For that, either different monitoring methods within the same sub-programme or indirect assessments with the help of other sub-programmes can be used. For example, an initial evaluation on pollution levels in the environment can be provided on the basis of species composition in ecosystems, as several species can grow/live only within certain ranges of environmental parameters (e.g. soil pH). Thus, it is possible to establish the state of the environment and to assess the need for additional studies without measuring the physical or chemical parameters. However, no terms of reference of the monitoring contracts incurred the obligation to consider alternative options to implement the monitoring programme.<sup>26</sup>

For example, in order to examine the air pollution simultaneously in many places, an alternative to constant measuring is to collect the long-term averages of the data as passive aggregates. Such an approach is used in the United Kingdom and Sweden<sup>27</sup>, and in case of more complicated compounds, such as the prerequisites of ozone, in many states all across Europe<sup>28</sup>. The World Health Organization has also emphasized that due to the expensiveness of air monitoring it should be exercised only in case of extreme necessity and occurred problems.<sup>29</sup> In addition to the methods providing long-term average results, it is recommended to use other indirect assessment methods (e.g. to monitor the biodiversity or the presence of indicator species)<sup>30</sup> and modelling for cheap alternatives. In Estonia, such cheap means are until now used only in scientific studies and in the control of models.

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<sup>24</sup> Valge, Maasikmets 2004. The Convention on Long-term Transboundary Air Pollution, Tallinn; Kimmel, V., Kaasik, M. Containing the air pollution in Europe and in Estonia. *Keskkonnatehnika* 5/2001, 14–16

<sup>25</sup> Tsyro, S. 2002. First Estimates of the Effect of Aerosol Dynamics in the Calculation of PM<sub>10</sub> and PM<sub>2.5</sub>, EMEP/MSC-W Note 4/2002

<sup>26</sup> NAO's analysis of the monitoring contracts from 2004–2005

<sup>27</sup> Bower J.S., Broughton G.F.J., Dando M.T., Lees A.J., Stevenson K.J., Lampert J.E., Sweeney B.P., Parker V.J., Driver G.S., Waddon C.J. and Wood A.J. 1991. Urban NO<sub>2</sub> concentrations in the U.K. in 1987 *Atmos. Environ.* 25B (2): 267–283

Ferm, M. and Svanberg, P.-A. 1998. Cost-efficient techniques for urban- and background measurements of SO<sub>2</sub> and NO<sub>2</sub>. *Atmospheric Environment* 32, 1377–1381

Svanberg, P.-A., Grennfelt, P. and Lindskog, A. 1998. The Swedish Urban Air Quality Network — A cost efficient long-term program. *Atmospheric Environment*, Vol. 32 (8), 1407–1418

<sup>28</sup> Bo R. Larsen Summary of the Expert Meeting/Workshop in a compendium Measurement of Ozone Precursor Volatile Organic Compounds (VOCs) Proc. Of the International Expert meeting, 13–30

<sup>29</sup> WHO, 2000. Air Quality Guidelines for Europe II 2nd edition. WHO Regional Office for Europe, Copenhagen

<sup>30</sup> Mulgrew, A., Williams, P., 2000. Biomonitoring of Air Quality using Plants. – WHO Air Hygiene Report 10, Berlin

In order to select the monitoring methods, use could be made of the system of problem-based environmental indicators, which gives a good starting point for choosing the necessary monitoring frequency and thereafter, the monitoring methodology (see also 1.1).

In developing different methods and additionally, in subsequent monitoring, it is essential to ensure that requirements are met. The Environmental Monitoring Act requires the use of accredited laboratories, but at present, this is not always observed. According to the Estonian Accreditation Centre, in December 2006, the hydro-biological lab in the Institute of Zoology and Botany lacked the necessary accreditation. Such a case has already occurred in Estonia – in analysing the data of the measuring programme of the Convention on Long-term Transboundary Air Pollution it was found that the monitoring results can be trusted only from 1994 onwards, when the labs were accredited, although monitoring was also exercised earlier in unaccredited labs.<sup>31</sup> If monitoring results are analysed in an unaccredited lab, the reliability of the results is problematic, their use in assessing long-term trends is limited and hence, the expenditure to obtain them is wasted.

### **The state environmental monitoring programme and those of local governments and enterprises do not complement each other**

It is essential that the environmental monitoring of different levels would be implemented according to common principles, as only then the results can be compared. According to the standpoints of the Monitoring Council and focus group, the best way to obtain data on the environmental state is through state environmental monitoring. Such an opinion is probably caused by the lack of monitoring at other levels, the low accessibility of this data and the higher credibility given to the state level. Common guidelines and rules would help to achieve that monitoring in local governments and enterprises is carried out everywhere according to same principles and their results could be used in addition to state monitoring or in the place of it. The establishment of general monitoring requirements is consistent with the intention of the Ministry of the Environment to transfer more monitoring load to enterprises.

So far, the environmental monitoring of local governments and enterprises has not been managed to launch successfully. According to the study of the University of Tartu,<sup>32</sup> no municipality has carried out environmental monitoring that would cover all monitoring fields. Only in few local governments, some parameters were monitored. In some local governments, the environmental monitoring is funded from the state budget, in some, not. In Tallinn, for instance, the air quality is monitored with state funds, but in other air quality monitoring stations, the municipalities contribute to the monitoring.

Majority of the enterprises affecting the environment either do not have any obligation to monitor or the commitment is not in correspondence with their impacts on the environment. In analysing the liabilities of the enterprises handling hazardous waste, the NAO found that the monitoring obligations of these enterprises are not in proportion with the environmental risks resulting from their activities. For example, environmental requirements were set only for a quarter of the enterprises handling hazardous waste<sup>33</sup>, although waste management is considered to be one of the priorities of the UN environmental programme because of its high environmental risk.

Also the Chancellor of Justice regarded in his annual report for 2005 that it is important to allocate the tasks of different monitoring levels more precisely. In analysing the problems of air quality, the Chancellor found that if no monitoring station has been established at state level, then pursuant to the Environmental Monitoring Act, the local government can organize the monitoring on its own, but it has no duty to do so.

As information on the environmental state is also provided by the monitoring of local governments and enterprises as well as by scientific studies, in planning the state monitoring, it should be analysed,

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<sup>31</sup> Pajuste, K., Kimmel, V., Kohv, N. and Truuts, T. 2003, Assessment of the Estonian EMEP data, available at <http://www.emep.int/assessment/estonia.pdf>

<sup>32</sup> [http://eelis.ic.envir.ee:88/seireveeb/index.php?id=13&act=show\\_reports&prog\\_id=-857228584&subprog\\_id=-183772935](http://eelis.ic.envir.ee:88/seireveeb/index.php?id=13&act=show_reports&prog_id=-857228584&subprog_id=-183772935)

<sup>33</sup> NAO's audit „Hazardous waste handling in intermediate depots and landfills”

which data is more practicable to be obtained from other monitoring levels. At present, this is not always taken into consideration, for instance, in 2006, third station for seismic monitoring was opened with one of its purposes to localize the man-made quakes (caused by the blasting in mines etc.). The responsibility to carry out such monitoring could be imposed on enterprises, but until now it has not been done so. As there is no requirement in international treaties and legislation that data should be collected at state level, the better organisation of the monitoring of local governments and enterprises would facilitate the fulfilment of international monitoring commitments.

Thus, in organising the environmental monitoring, insufficient attention has been currently paid to analysing the optimality of monitoring sites, frequency and methodology. As a result of the spontaneous development of the monitoring programme, some parameters may not be monitored at all. The monitoring of local governments and enterprises has not been managed to launch successfully. As the monitoring fields are not determined and the monitoring results are little analysed, the monitoring is carried out in too many places or too often in some monitoring fields, and at the same time, not all crucial environmental problems and parameters can be monitored.

### **Recommendations to the Minister of the Environment**

- To determine the monitoring need (incl. problems, areas to be monitored) based on priority environmental fields and the factors affecting them, and by doing so, to take into account the needs of the users of monitoring results and involve the specialists of respective fields. This will ensure that environmental monitoring is kept up to date even in a rapidly changing economic situation and that crucial environmental problems are addressed first.
- To prepare a long-term environmental monitoring programme by involving also the monitoring currently exercised by subordinate agencies, as well as the environmental monitoring activities of other ministries and local governments. Such an arrangement enables to decide more efficiently over the factors to be monitored in the environment, while it also raises society's confidence that problematic environmental fields are subject to data collection.
- To analyse the environmental monitoring need by regions and to establish requirements in the National Environmental Monitoring Programme for the environmental monitoring of local governments and enterprises. This would reduce the possibility that the problems that require monitoring will remain unconsidered at the local level.
- To update the existing system of environmental indicators and based on this, to choose the parameters of environmental monitoring. This would enable to conform Estonia's monitoring system to the international system and to adjust monitoring so it would be possible to gain information on environmental problems.
- To assess the monitoring methodology and the temporal and spatial density of the monitoring programme in order to develop an optimal monitoring network. Such an assessment renders the organisation of monitoring more optimal and helps to identify the links between causes and effects.

## 2. Analysis and disclosure of environmental monitoring data

In order to use environmental monitoring data for planning the environmental measures, assessing and correcting the results, the data must be analysed and the results of the analysis must be made available. The monitoring data is easily accessible if they are assembled into one place and disclosed after the measuring as quickly as possible.

### 2.1. Environmental monitoring results are difficult to access

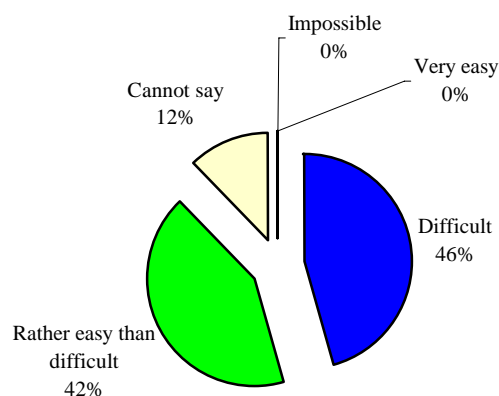
Pursuant to the Environmental Register Act, from 1 July 2005, the data of state environmental monitoring must be assembled in the Environmental Register, which is developed by the Environment Information Centre of the Ministry of the Environment as its authorized processor. The Act provides that, among others, the Environmental Register must also include the records of natural resources, natural objects, biological environmental factors, the state of the environment, natural environmental factors and waste (incl. radioactive waste). The Environmental Register is an electronic database, in which data is entered on registry cards and which, pursuant to the law, has to be accessible to the public via data communication network.

In every fourth year, the Environment Information Centre publishes an Environmental Review, which comprises of generalized tables, regional maps of environmental information and concluding texts.

In spring 2006, the Environment Information Centre as the current coordinator of the monitoring support programme carried out a questionnaire on the availability of the environmental information.<sup>34</sup> The questionnaire addressed the environmental information in general, not only the information obtained as a result of environmental monitoring. The questioning revealed that only about 40% of respondents were satisfied with the availability of the environmental information.

In the same spring, the NAO asked the opinion of the County Environmental Departments staff on the use of environmental monitoring data. 57 employees replied to the questionnaire. In majority, the opinions regarding whether the necessary environmental monitoring information is easily accessible or not fell into two (see figure 2). Presumably, the opinion is dependant on the characteristics of the used data.

**Figure 2.** The opinion of the County Environmental Departments on the accessibility of environmental monitoring information



Source: NAO's questionnaire

<sup>34</sup> The questioning involved 982 ordinary citizens, 337 educationalists and 190 officials from local governments. The results are available at the web-page of the Environment Information Centre [www.keskkonnainfo.ee](http://www.keskkonnainfo.ee)

## **The data is not assembled into one central register**

Many officials of the County Environmental Departments regarded as a problem that the use of data requires a lot of time, as the data must be found from different institutions and it is not always known, which institution should be addressed. In the case the data is obtained from several sources, it is also difficult to decide, which data is more suitable to use, especially if the background information (the time, places and methodology of measuring etc.) is not available.

According to the explanations of the Environment Information Centre, the digital solution of the Environmental Register is currently being developed and the data of the Register is planned to made publicly available at one Internet site only.

Although the Environment Information Centre has been the administrator of monitoring data and managed the environmental monitoring support programme since 2005, the common Internet portal presenting the environmental monitoring data was launched only in November 2006. In January 2007, the web-page of the Environment Information Centre provided links to „Environmental Register“ and „National Environmental Monitoring Programme“, which contained the introductions of sub-programmes and annual reports. A map interface is being developed in order to present the monitoring results from different stations by sub-programmes.

In most respects, the environmental monitoring web-page provides monitoring reports by years. However, there were reports missing with regard to the monitoring of the environment and health, groundwater, biodiversity and landscapes, and radiation. Regarding the monitoring of wildlife and landscapes, for example, about one fifth of the sub-programmes' reports were missing – 44 out of 57 sub-programmes had reports covering at least one year.

As the data in the reports and tables of sub-programmes is presented in different formats, the comparative analysis of this data is complicated and requires a lot of work from the users.

The results of the environmental monitoring of local governments and enterprises are not integrated into the Environmental Register, but they are distributed between different institutions – some of them in the County Environmental Departments, the results of scientific studies in academic institutions etc. Different institutions possess a lot of information on the state of the environment, but no agreements have been made to consolidate them and therefore, they are difficult to access. The focus group also emphasized that several institutions are monitoring the environment within the same field, but the results are not assembled: for example, the state of groundwater is monitored by the Ministry of the Environment, the Ministry of Social Affairs, local governments, scientific institutions; and the state of soils by the Ministry of the Environment and the Ministry of Agriculture. The consolidation of the existing data and disclosure of their results would minimize the risk of duplicating the monitoring and provide possibilities for additional analysis.

Some institutions organising the monitoring have created their own databases (e.g. the Radiation Protection Centre, the air monitoring data of the Estonian Environmental Research Centre in the air management system AirViro, the forest monitoring of the Centre of Forest Protection and Silviculture).

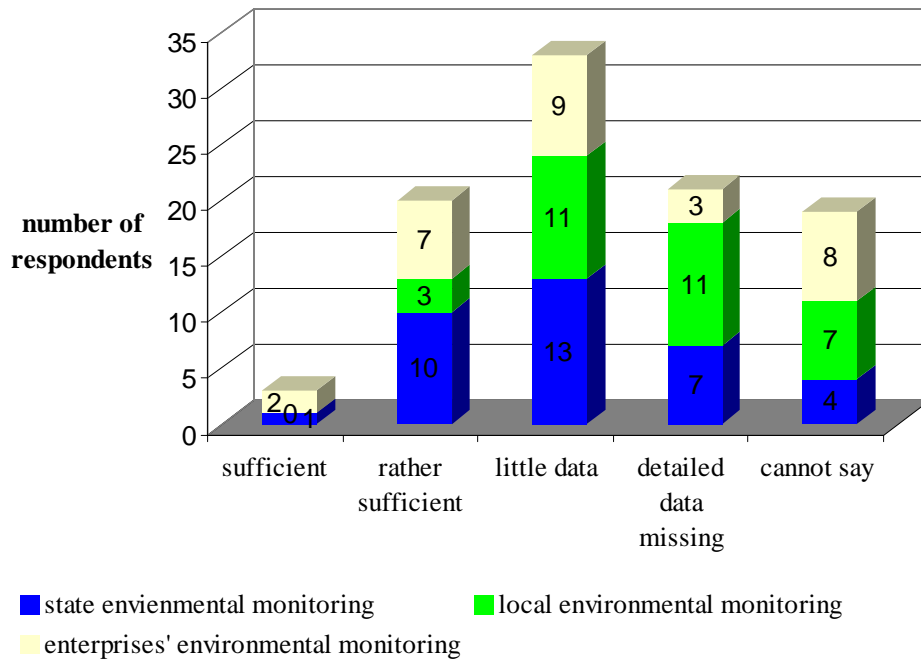
According to the Environment Information Centre, the environmental information is dispersed between more than 40 databases. All databases are not available for full use for the environmental officials and the public, because the data gathered in them is yet to be interconnected. The Environment Information Centre finds that the unrelated data will cause different and possibly incorrect interpretation at the international level, as well as in preparing the development plans and local plans.

## **Little detailed data is available**

It is not entirely clear, which data must be guaranteed to be accessible. For example, the time required to present the initial monitoring results varies largely. Only in few fields, the data is constantly made publicly available via the Internet (e.g the parameters measured in ambient air). The disclosed results provide no essential background information, for example, what region is represented by the results,

and whether and how the results could be extrapolated to other areas. Likewise, the running data is not available in the Environmental Register (e.g. meteorological observations and forecasts).

**Figure 3.** The opinions of County Environmental Departments on the accessibility of detailed monitoring information



Source: NAO's questionnaire

number of respondents > state environmental monitoring, local environmental monitoring, enterprises' environmental monitoring > sufficient, rather sufficient, little data, detailed data missing, cannot say

In their replies, the County Environmental Departments also found that they need detailed data and the background information of measurements, but these are not available. This complicates the use of information on the environmental state in local decision-making (in issuing environmental permits, assessing the local plans and environmental impacts etc.). Many believe that also the reviews of state environmental monitoring are too general to make concrete decisions. For example, the environmental monitoring maps with regional data are published in very small format, providing no information on local environmental state. The employees of the County Environmental Departments also revealed that state monitoring points are located too sparsely to take decisions at local level. Pursuant to the Environmental Monitoring Act, the state environmental monitoring could be complemented by the monitoring of local governments, but mostly the municipalities exercise no environmental monitoring on their own. Also the Ministry of the Environment admits the need to develop the environmental monitoring of local governments. In 2000 and 2001, respective trainings were organized for the officials of the County Environmental Departments and local governments.

Specialists, who use mostly the primary data, need additional background information on the methodology of measuring. According to metrology, it is not possible to assess the reliability of the measuring results if the measurement uncertainty<sup>35</sup> characterising the accuracy of the result is not known and hence, the data cannot be used in scientific studies. Some reports gave information on the reliability of results, but did not disclose the measurement uncertainties, although these should be

<sup>35</sup> Pursuant to the Metrology Act, the measurement uncertainty is a parameter associated with the result of measurement, which characterises the values that could be reasonably attributed to the measurand.

similarly provided pursuant to the Metrology Act (customized to the EU rules) in order to ensure traceability. As the data on the environmental state could be obtained through random measurements<sup>36</sup> in addition to the constant monitoring in stations, the disclosure procedures for such results need careful consideration.

### **Data is disclosed too late**

The officials of the County Environmental Departments found that often the monitoring data cannot be used because it is out of date. Predominantly, the monitoring reports of previous years together with data files are submitted in February next year and approved within some months. According to the Environmental Register Act, it is not mandatory to disclose the monitoring data which is yet being processed. As the time allocated for data processing is nowhere fixed, a lot of data is disclosed only by the time the reports are published. After some time, the data is also entered into the database administered by the Environment Information Centre. Thus, majority of the environmental information is possible to be seen only within 1.5 years after the measurements were carried out. Such a shift in time was regarded as a significant shortcoming in the use of monitoring data by several officials of the County Environmental Departments and also by the focus group.

Thus, it is complicated to use the environmental monitoring results in decision-making (in issuing environmental permits, assessing the local plans and environmental impacts etc.), as the majority of the data is not available to the public and officials, because the Environment Information Centre of the Ministry of the Environment has not been able to assemble most of the environmental data into the Environmental Register.

## **2.2. Monitoring data is not disclosed in a user-friendly manner**

In order to make full use of the monitoring results, the relevant background information must be enclosed and the results presented in a manner understandable to the user. A good environmental management should result in an information satisfying all user groups to a large extent. In order to disclose the monitoring results in a user-friendly way, the needs and expectations of different users must be known.

To analyse the users of environmental monitoring, the NAO organised a focus group, questioned the staff of the County Environmental Departments and requested the opinion of the Expert. The participants of the focus group regarded international organizations, the European Commission and other EU institutions, ministries, local governments, environmental impact assessors, scientific institutions, students, the public and non-governmental organizations as the users of monitoring data. While the information needs of international organizations follow from the legislation (directives, conventions, bills), the expectations of the majority of other users have not been clarified. Likewise, it was emphasized at the monitoring forum in 2003<sup>37</sup> that the state, public and private interests in using the monitoring information need to be specified.

The questioning of the staff of County Environmental Departments revealed in what forms they would like to receive the information (see table 3). Most of the officials request graphic information in addition to the reviews of environmental fields, but this is little offered by the current representation of the data.

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<sup>36</sup> For example, the series of measurements carried out by the air monitoring bus at about weekly intervals in County centres definitely need the additional information that pursuant to the directives, the results are sufficiently representative only in case of 14% timely coverage.

<sup>37</sup> The monitoring forum in Tartu on 26 March 2003 „Monitoring problems, processes and consequences“

**Table 3.** The expectations of the County Environmental Departments regarding the forms of disclosing the environmental monitoring results

|  | Yes, definitely needed | Also needed | Not needed in work | Cannot say |
|--|------------------------|-------------|--------------------|------------|
| General reviews that interconnect different fields                         | 12                     | 21          | 4                  | 1          |
| Field-specific reviews and data (statistical and measuring data)           | 32                     | 4           | 0                  | 2          |
| Figures and tables, which present primarily problematic fields and changes | 26                     | 12          | 0                  | 0          |
| General maps   | 13                     | 19          | 2                  | 2          |
| Scientific articles  | 3                      | 15          | 7                  | 10         |
| Popular science literature (articles and compendiums)                      | 3                      | 20          | 3                  | 9          |
| Other  | 0                      | 0           | 0                  | 3          |

Source: NAO's questionnaire

The officials of the County Environmental Departments found in their replies to NAO's questionnaire, that the available information is often difficult to use. For example, the Internet provides maps with monitoring stations, but there are no comments as to what activities are carried out in a particular station and where can the monitoring results be found. The unevenness of disclosure forms was also regarded as a significant shortcoming: detailed primary information is provided in some fields (e.g. air monitoring), generalized data in others, but in almost all fields the two are not provided together. Only few officials regarded the availability of generalized data to be sufficient. A third of the respondents found that too little generalized data is provided about all levels of environmental monitoring, and regarding the environmental monitoring of local governments and enterprises, it was found by one seventh and one ninth of the respondents respectively that such data is missing altogether.

The Experts involved in the audit assessed the use of monitoring data also from the standpoint of scientists. The Environment Information Centre replied NAO's enquiry to receive long-term data on the precipitation chemistry in open fields by sending 956 files, which were very difficult to use because of their different formats and structure. In reformatting the data and removing the measuring mistakes, different users can end up with different data files. Likewise, the Experts could not find any system in the names of files, while the files also lacked information as to where and with what means the measurements were carried out and how the samples were collected. At the same time, in respect of 5 monitoring stations, where the information is constantly forwarded to the Statistics Estonia, data covering the whole observed period was obtained as a compact file from the web-page of the Statistics Estonia. According to the Experts, an Internet-based database should be created to improve the possibilities of data use, by considering carefully what structure the database should have and what data is needed to be provided (e.g. the measuring time and station, the parameter measured). In the opinion of the Experts, the careful consideration of the structure and establishment of a system analogous to the one in the Statistics Estonia would improve the possibilities of data use significantly.

In 2000, the University of Tartu as a coordinator of the environmental monitoring support programme at that time examined the opinions regarding the ways of disclosing the monitoring results. Most importantly, the scientists made observations<sup>38</sup> regarding the processing of results: no predictions had been made on the basis of the data and despite the developments in information technology, the time spent on data processing had not decreased and the data exchange had not simplified. Likewise, it was found at the monitoring forum in 2003 that the information on the environmental state should be distributed in a way in which the data would be unequivocal and commonly understandable.

In the course of the audit, the NAO learnt how the monitoring information is provided in the public databases of other states (Germany and Norway) and the European Environment Agency. The results

<sup>38</sup> The explanatory memorandum of the state environmental monitoring programme, the appendix to the decree no. 85 of the Ministry of the Environment from 21 February 2000

of environmental monitoring were presented on maps, with additional links to reports and articles, thus enabling specialists and other interested persons to gain more specific information from the same web-page. A good example of the problem-based data disclosure is the web-page of the European Environment Agency ([www.eea.europa.eu](http://www.eea.europa.eu)), where after choosing a theme, the visitor is directed to characteristic environmental indicators, general reports and other relevant sub-themes or fields. A good approach can also be found at the web-page of the Norwegian Institute for Air Research ([www.nilu.no](http://www.nilu.no)), where under the related problems, the visitor is guided to access technical as well as other works published on the given subject. Likewise, the web-page of the Federal Environment Agency in Germany ([www.uba.de](http://www.uba.de)) enables to move on to the sites containing the problem in the interest of the user and/or the aggregate of the data. The above-described sources of information are easily usable to the public as they provide essential links between causes and effects, maps, background information and numerous general analyses.

In Estonia, the results of environmental monitoring are published as annual reports of sub-programmes, where the long introductions are replicated from year to year. Said annual reports are difficult to use, because in order to analyse various environmental changes, the user must assemble the data from different years and reports of the sub-programmes on her own. In Statistics Estonia, for example, the ways of disclosing the environmental data are much more user-friendly: in making an enquiry, one can choose both the recommended parameters and the forms of representation (table, figure, file in many formats).

In addition, the system currently in use, where the overview on the environmental state is disclosed with annual reports and overall reviews published in every fourth year, is too specialist-oriented in its content. There are too many facts and opinions presented, whereas the essential is not provided – is the state of the environment anywhere significantly worsened, which are the changes that require more attention and what can be expected in the future.

Similarly, the final report of the Phare programme “Air quality management: issues for EU accession” published in 2001 addresses the issue of disclosing the monitoring data in a manner suitable for its use. The report gives recommendations for creating the database of ambient air, and also describes many modes to present the information in graphic forms (maps of pollution levels). It is also emphasized that all the figures and materials to be presented require correct verbal interpretation and every theme should also enclose a simple overview of the problem, its causes and trends.

The officials of local governments found<sup>39</sup> that the environmental data as an inherently spatial data should be largely accessible in the form of maps. The Environment Information Centre has undertaken to link the monitoring results with maps, but in December 2006, the outcomes of this process were yet not possible to assess. If the data analysis results in the preparation of maps based on generalized information (even better, layers of maps, which could be related to other spatial data), then the need for background information is minimized, as it is already taken into account in the generalization. The needs of the officials of local governments could be met by preparing problem-based Estonian maps, where the existing monitoring results and other information are generalized by estimated zones, and sensitive areas and potentially critical environmental parameters are highlighted.

The environmental monitoring provides essential information, on the basis of which the links between the state of human health and the environmental factors affecting it can be analysed. For example, the groundwater in Northern and Central Estonia contains sufficient amount of fluoride recommended for the human health. As the excessive daily intake of fluoride will lead to dental cavities the fluoride-containing toothpaste should not be used in these regions. But as this information is not visually disclosed and the public is not informed, many citizens harm themselves unintentionally and thereby, also increase their healthcare expenses.

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<sup>39</sup> The questionnaire of the Environment Information Centre for the officials of local governments. - <http://www.keskonnainfo.ee/ts/ylevaade/kov/>

Thus, the monitoring data is not analysed to provide information in a user-friendly manner and the disclosed results are not easily usable. Providing the information suitable for all users is complicated by the fact that up to now, it is not found out, who and for what purposes needs the monitoring results. As the monitoring results are little generalized and the monitoring stations are mostly not located in the vicinity of the planned activities, it is difficult to use the monitoring results in issuing environmental permits, preparing development plans and making other decisions. Consequently, the utilization of monitoring results for making decisions necessary to anticipate the environmental damage is hindered, for example, in the environmental management and planning.

### **2.3. The causes and effects of the changes in the environmental state are not analysed**

Environmental monitoring is efficient if in analysing its results, the activities causing environmental problems are identified, the range of environmental changes is assessed and their consequences (e.g. damage to ecosystems, increase in human illnesses or mortality) are predicted, and if necessary, citizens are informed. The data of environmental monitoring together with the causes of changes and future predictions found out by the analysis is needed to conduct several essential analyses: e.g. cost-benefit analysis<sup>40</sup> and risk analysis, which is carried out for the assessment of major accidents, health and environmental risks.

Up to now, the recommendations made in the 2000 monitoring programme are not fully implemented: to start with a generalizing analysis of monitoring data and to improve the data analysis and management by using info-technological means. In monitoring reports, the implementers of sub-programmes do compare the results with the ones from the last couple of years, but in most cases they do not compare them with long-term data or other monitoring programmes.

The issue of monitoring results analysis was also addressed at the monitoring forum “Monitoring problems, processes and consequences” in Tartu, spring 2003. At the forum, it was claimed that different monitoring programmes need to be thematically linked by using expert groups. It was emphasized that as in many fields the pollution load and natural state are not known the links between causes and effects are impossible to assess. Often, the possibilities to identify the links are also restricted by the selection of monitoring parameters.

Although finding the causes of pollution is the first step in reducing contamination, the possible causes of environmental changes are often not analysed. For example, it is yet to be discovered what causes the significant increase in the level of ambient air pollution with fine solid particles in every spring. This constitutes a crucial problem, as according to the WHO model analysis, such pollution causes up to 600 premature deaths in Estonia every year (see also 1.1).<sup>41</sup> There has been no assessment regarding how much and to what extent illnesses, losses in labour and hence also the decline in GDP have resulted from the environmental pollution. According to the Environmental Strategy, conducting of such analyses is impeded because of the low development of environmental health science in Estonia.<sup>42</sup> In Finland, the problem of air pollution with aerosols has repeatedly emerged and the analysis of monitoring results has revealed that the aerosol pollution there is to some extent caused by the grass fires in Estonia in every spring and the pollution from electric power plants.<sup>43</sup>

The Environmental Monitoring Act has claimed the assessment of the environmental state and the prediction of its changes to be one of the purposes of environmental monitoring. Currently, the state of

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<sup>40</sup> Sivertsen, B. 1997. Air Quality Monitoring and Applications, Kjeller NILU TR Report 11/97

<sup>41</sup> Health risks of particulate matter from long-range transboundary air pollution World Health Organization 2006

<sup>42</sup> The Environmental Strategy up to 2030

<sup>43</sup> Pääkaupunkiseudun yhteistyövaltuuskunta (YTV) 2002, Hiukkasten kaukokulkeuma syyskuuss 2001, Helsinki, Ilmansuojelu, 2003, Studies on the Long-range Transport Episodes of Particles in Finland in March and August 2002 Ilmansuojelu 2/2003 8-9 ([http://www.ytv.fi/ilmanl/aineisto/kaukokulkemaepisodi\\_2003.pdf](http://www.ytv.fi/ilmanl/aineisto/kaukokulkemaepisodi_2003.pdf))

the environment is predicted on the basis of monitoring results only in few cases. An example of such predictions is the presentation of monitoring results as a mapped information on the web-page of the Estonian Meteorological and Hydrological Institute, such as the maps of the forest fire hazard in summer, the snow coverage in winter and the meteorological information. Similar information provided for other environmental parameters would be much more understandable to many users than the tables and graphs, which need a lot of time to be found in the sub-programmes' annual reports of hundreds of pages.

One of the reasons for little long-term analysis is that in many fields, the data from previous years is stored on paper or on electronic media which have become obsolete. Only in 2005, requirements about the forms of presenting data were established in the monitoring contracts and therefore, the data formats from previous years differ by different years, and also by different sub-programmes. Likewise, the earlier maps require replacement of computer programmes and digitalization of the data on paper. According to the explanations of the Environment Information Centre, it will take at least a year to digitalize the old data and they need additional workforce for that.

Dangerous changes in the environmental state can be anticipated in the course of the planning of activities, but as the environmental monitoring results are not analysed, there is no information available for decision-making. Pursuant to the Environmental Register Act, Article 20, the register must contain a “list of areas for reduction of adverse impact of human activity”, pursuant to the Article 30, a “list of danger areas arising from man-made environmental factors”, and pursuant to the Article 33 a “list of areas endangered by natural environmental factors”. Compiling of all these lists needs the analysis of monitoring results in order to enter the descriptions of the causes of environmental risk onto register cards. The law does not provide any deadlines for preparing the above-described lists, and none of the lists has been completed to date.

The lists of restricted areas stated in the Environmental Register Act (Articles 20, 30, 33) do not include the areas of high contamination level, where no more economic activities should be added. The need for such an information has been claimed in the course of environmental impact assessment, as at present, establishment of new industries or activities is not explicitly prohibited in certain areas, although it would be justified. For example, in Kohtla-Järve, a new factory for producing oil-shale oil is planned to be established at an already contaminated site, regardless that the earlier semi-coke dumps there have not been made environmentally safe.

Thus, because of the little analysis of environmental monitoring data, it is not possible to find out all causes of environmental changes and to make predictions for future. As the measured environmental parameters are not related to the activities that caused them, the measures which have been successful in improving the environmental state are also not known. Due to the little analysis, no conditions can be set in the environmental permits regarding the economic activities and environmental monitoring of enterprises.

### **Recommendations to the Minister of the Environment**

- To find out, what environmental monitoring data and in which forms do the users of monitoring information require, and to take this into consideration in planning the monitoring, and in analysing and presenting the results.
- To develop procedures for disclosing the environmental monitoring results, considering the needs of different users groups. For example, to create a two-tier database, which would provide the public with generalized data in the form of visualised maps and tables, while registered users (e.g. officials, scientists, interest groups) could also access primary data together with metadata. Careful consideration of disclosure procedures facilitates more efficient use of resources, since less time is spent on responding to enquiries.
- To initiate amendments to the Environmental Monitoring Act in order to set new deadlines for entering the data into the Environmental Register and to require the submission of all data

obtained in the course of environmental monitoring (incl. the monitoring activities of enterprises and local governments) to the Register. The inclusion of all environmental monitoring data into the Environmental Register is necessary for gaining a better overview of the state of the environment in different regions.

- In addition to state environmental monitoring, to integrate also the environmental monitoring results of other ministries, local governments and enterprises into the Environmental Register and/or refer to them in the set of links in the Register. The consolidation of the environmental monitoring results of different institutions and levels enables to improve the consideration of the environment in decision-making and facilitates the national studies not only in the field of environmental monitoring but also in other fields.
- To require the institutions responsible for monitoring to perform a more detailed analysis on the environmental monitoring and other environmental information collected (the sources of pollution, study results, indicators of health), which would explain the long-term trends, causes of changes and predictions, as well as consider the cumulative impact of different environmental factors. The detailed analysis of environmental monitoring results enables to understand the links between causes and effects and to present the results by figures, graphs, maps of predictions and tables, i.e. in forms that are more comprehensible to users, highlighting the areas of higher environmental risk.
- To set fixed deadlines for entering the necessary information into the Environmental Register (incl. the list of risk areas). Assembling the data in the Register produces the environmental information needed for decision-making, provides a better overview of the state of the environment and helps to avoid situations, where new environmentally dangerous activities are planned in already contaminated areas.

/signed digitally/

Tarmo Olgo  
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