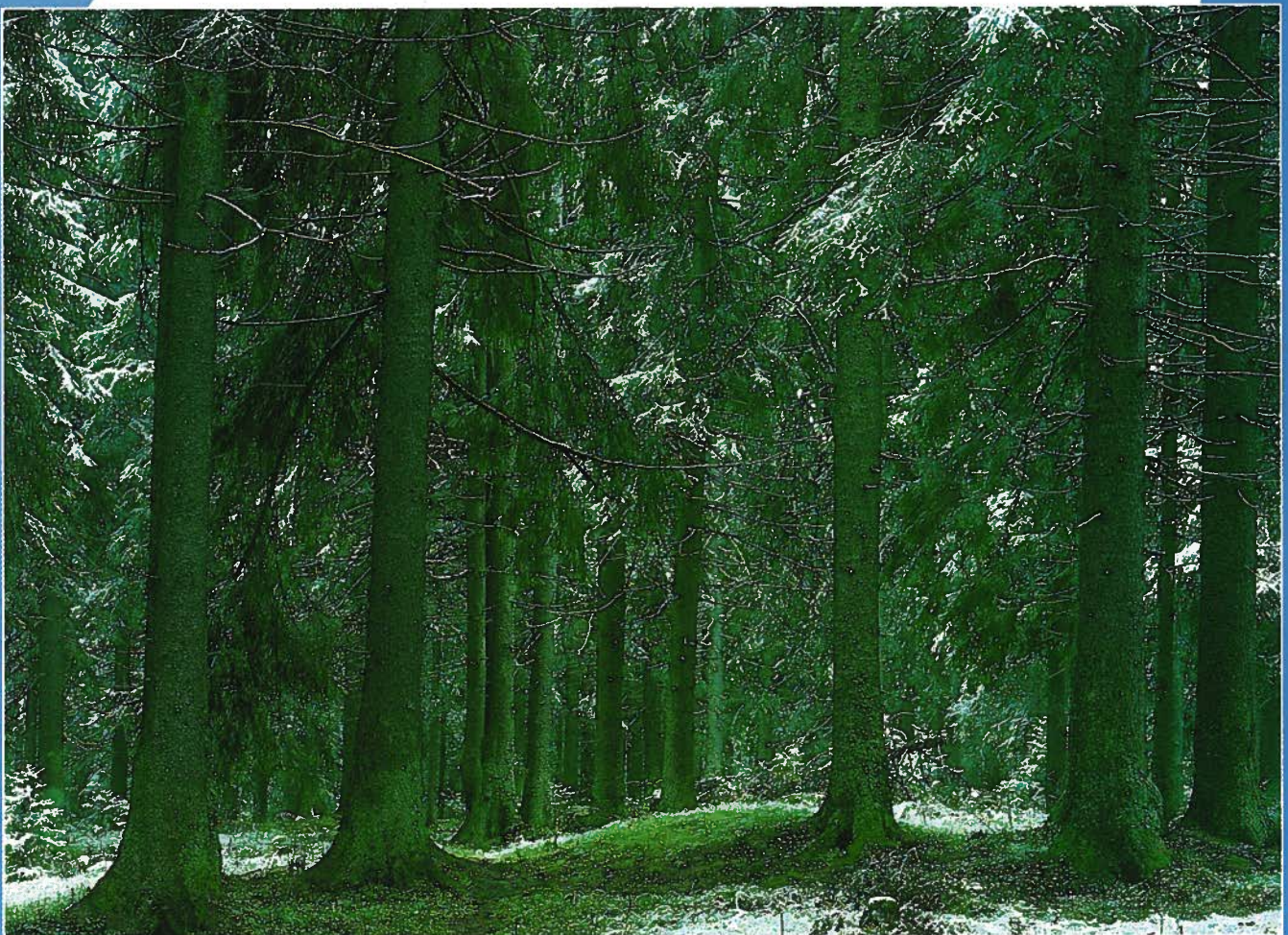




**ENVIRONMENTAL  
PROTECTION**

**Kristina Saarinen, Timo Jouttijärvi and Kaj Forsius**

# Monitoring and Control Practices of Emissions in Pulp and Paper Industry in Finland





Kristina Saarinen, Timo Jouttijärvi and Kaj Forsius

Monitoring and  
Control Practices of  
Emissions in Pulp and Paper  
Industry in Finland

HELSINKI 1998



441 057  
Painotuote

ISBN 952-11-0308-6  
ISSN 1238-7312  
Cover photo: First snow by  
Jorma Peiponen  
Page-layout: DTPage Oy  
Printer: Oy Edita Ab  
Helsinki 1998

# Contents

.....

|   |           |
|---|-----------|
| <b>I LEGISLATIVE BASIS AND MONITORING SYSTEM.....</b>                   | <b>5</b>  |
| <b>1 IPPC directive and monitoring.....</b>                             | <b>5</b>  |
| <b>2 Finnish Environmental Legislation .....</b>                        |           |
| <b>3 General Principles in Monitoring .....</b>                         | <b>7</b>  |
| 3.1 Need for monitoring .....   | 7         |
| 3.2 Monitoring data .....   | 7         |
| 3.3 Self-monitoring and inspections .....                               | 8         |
| 3.4 Operation monitoring .....  | 8         |
| 3.5 Integrated monitoring, a multi-media approach .....                 | 9         |
| 3.6 Harmonization and quality assurance .....                           | 9         |
| <b>4 Emission Monitoring System in Finland.....</b>                     | <b>10</b> |
| 4.1 Emissions into the air.....   | 10        |
| 4.2 Wastewater discharges .....   | 11        |
| 4.3 Solid wastes .....  | 13        |
| 4.4 Noise immissions .....  | 14        |
| <b>II EMISSIONS INTO THE AIR .....</b>                                  | <b>15</b> |
| <b>1 Generation of Emissions into the Air and Emission Limits .....</b> | <b>15</b> |
| <b>2 Control Technology .....</b>                                       | <b>16</b> |
| <b>3 Measurements .....</b>   | <b>16</b> |
| 3.1 Periodical measurements .....                                       | 16        |
| 3.2 Continuous measurements .....                                       | 17        |
| 3.3 Sampling, analysis and calculation .....                            | 18        |
| 3.4 Factors influencing on a successful emission measurement.....       | 19        |
| <b>III WASTEWATER DISCHARGE MEASUREMENTS .....</b>                      | <b>20</b> |
| <b>1 Wastewater Generation and Emission Limits .....</b>                | <b>20</b> |
| <b>2 Treatment .....</b>  | <b>20</b> |
| <b>3 Measurements .....</b>   | <b>22</b> |
| 3.1 Parameters .....  | 21        |
| 3.2 Flow measurement.....   | 21        |
| 3.3 Sampling .....  | 21        |
| 3.4 Analyses.....   | 22        |
| 3.5 Calculation .....   | 23        |
| 3.6 Factors influencing on a succesful emission measurement .....       | 23        |

|   |           |
|---|-----------|
| <b>IV SOLID WASTES .....</b>  | <b>24</b> |
| <b>1 Generation .....</b>   | <b>24</b> |
| <b>2 Waste management .....</b>   | <b>24</b> |
| <b>3 Measurements .....</b>   | <b>25</b> |
| 3.1 Properties of solid wastes .....                                      | 25        |
| 3.2 Monitoring of landfill gases .....                                    | 26        |
| 3.3 Monitoring of landfill waters, surface waters and ground waters ..... | 26        |
| <b>Sources.....</b>   | <b>27</b> |

# Legislative Basis and Monitoring System

---

## 1 IPPC Directive and Monitoring

Council Directive 96/61/EC of September 1996 concerning integrated pollution prevention and control (in this report referred as IPPC directive) gives directions for an integrated environmental permit.

In article 9 it is required that the Member States shall ensure that the permit includes all measures necessary in order to achieve a high level of protection for the environment as a whole by means of protection of the air, water and land. The permit shall include emission limit values for pollutants, in particular those listed in Annex III, likely to be emitted from the installation concerned in significant quantities, having regard to their nature and their potential to transfer pollution from one medium to another (i.e. water, air and land). The limit values may be supplemented or replaced by equivalent parameters or technical measures. The permit shall also contain measures relating to conditions other than normal operation conditions (e.g. start-ups, leaks, malfunctions, momentary stoppages and definitive cessation of operations). According to the article, the permit shall contain suitable release monitoring requirements, specifying measurement methodology and frequency, evaluation procedure and an obligation to supply the competent authority with the data required for checking compliance with the permit.

The operator shall, according to article 14, regularly inform the competent authority of the results of the monitoring of releases and without delay of any incident or accident affecting the environment, and afford the competent authority all necessary assistance to enable them to perform their duties for the purposes of the directive.

In addition to the traditionally measured parameters for water and air emission monitoring, new monitoring requirements are set by the integrated approach: usage of resources (raw materials, chemicals, water and energy) and noise abatement pertain to integrated monitoring. It is necessary to focus on relevant parameters in the monitoring of emissions and their impacts in order to be able to assess the correlation between the emissions and their impact on the environment properly and more cost effectively.

Permit provisions for monitoring should be changed if the operation does not correspond to the prevailing conditions when the permit was granted, or the needs of monitoring of the environment and supervision.

## 2 Finnish Environmental Legislation

Finland has no single environmental law at the moment. The environmental legislation is composed of a number of individual acts. A new Environmental Protection Act is currently under preparation and will combine the environmental acts according to the requirements of the Council Directive 96/61/EC of September 1996 concerning integrated pollution prevention and control (IPPC).

Presently, the integrated approach is included in the two separate permit procedures: the environmental permit procedure according to the Environmental

Permit Procedure Act (735/1991) and Decree (772/1992) and the water discharge permit procedure according to the Water Act (264/1961) and Decree (282/1962).

The Environmental Permit Procedures Act combines the permit procedures of the Air Pollution Control Act and Decree, the Waste Act and Decree, the Health Protection Act and Decree and the Adjoining Properties Act. The competent authority in environmental permit matters is, depending on the line of activities, either the Regional Environment Centre or the local environmental board.

When discharging waste waters, the Regional Environment Centre must be notified in advance regarding any plans for the discharge of wastewater in the cases listed in the Prior Notification Decree. The Centre assesses the notification and judges whether the activity will cause water pollution. If the pollution is unavoidable, the polluter must apply for a permit from the Water Court or from the local environmental board. Substantial polluters send their applications directly to the Water Court. Polluting of groundwater is totally forbidden; this means that no permit can be granted for discharging pollutants into the groundwater.

In pulp and paper industry, an environmental permit granted by the Regional Environment Centre and a water discharge permit granted by the Water Court are needed.

Although the environmental legislation is based on a sectoral approach, the permit system in each sector follows certain uniform lines including the following elements (both in environmental and water permit matters):

- An application describing the activity and its environmental effects is to be submitted to the competent authority. The data and information that the operator of an industrial plant (the applicant) has to submit in the form of an application to the authority is prescribed in the above mentioned Acts and Decrees.
- The documents are public and the persons and organizations affected by the project have a right to comment on them.
- The competent authority makes a decision including emission limits and other permit conditions.
- Those concerned have a right to appeal against the decision.
- A revision of the decisions and permit conditions is made by a certain deadline stipulated in the permit (3-10 years when wastewater discharges are concerned) or when there are significant changes in operation or emissions or when unexpected effects are detected.

Right at the preliminary stage of planning a new establishment, the necessary permits and environmental aspects are to be surveyed. The enterprise is expected to recognize that the environmental criteria may affect siting as well as other economic and technical decisions. Even in the case of changing the production, raw materials or technical devices at an existing plant, the authorities must be informed as soon as these decisions are made, and negotiations shall be initiated to survey the possible need for renewing the permits.

The legislation is based on the Polluter Pays Principle in the sense that the polluter pays all pollution abatement costs, which include also the monitoring costs. In addition, polluters of watercourses are obliged to pay indemnities to the owners of water and shore areas as well as to professional fishermen for any damage caused. A typical feature of the permit procedure is the case-by-case consideration of applications and tailor-making of the permit conditions. The permit conditions are expressed as emission limits and compulsory measures and not as technical standards.



## **3 General Principles in Monitoring**

### **3.1 Need for monitoring**

The purpose of monitoring of emissions is to clarify at adequate accuracy the emission levels and their changes in normal operation and to ensure that the operation fulfils the provisions laid down in the permit.

The information of the emission and impact monitoring is used:

1. by the operator to maintain production and product quality as well as to acquire information of emissions;
2. by the supervisory and permitting authority for making decisions in permit matters, for assessing the efficiency and adequacy of emission control measures, to evaluate the impacts of the activities on environmental quality, to evaluate harm caused by pollution, to consider need for further pollution prevention acts;
3. by public, media and environmental groups; and
4. by the Ministry of the Environment and the Finnish Environment Institute for planning, reporting etc.

### **3.2 Monitoring data**

Finnish environmental legislation requires the operator to be aware of the amount and composition of the emissions as well as of the efficiency of the purifying method/ equipment used, and also of the impacts on environment caused by the operation. Although the Finnish environmental legislation is based on a sectoral approach, the monitoring provisions for emissions into the air, wastewater discharges and emissions from solid wastes follow uniform lines.

General requirements for monitoring are determined by the information required by the authorities and by the process control. Monitoring requirements needed for control of the permit provisions are written down either in the environmental permits or in separate emission monitoring programmes, which are approved by the competent authority. The emission levels and their changes in normal operation need to be clarified at adequate accuracy. The plants have to inform the authorities of the methods used in monitoring. They also have to assess the reliability of the data they have submitted. There are guidelines for monitoring of emissions into the air as well as for monitoring programmes, self-monitoring and sampling practices for wastewater discharges. A system based on a quality management system and "total uncertainties" according to ISO Guide 24 is under development.

The monitoring results are reported to the authority according to the specific monitoring programmes, e.g. once a month. Furthermore, each plant is obliged to submit an annual report on monitoring results to the competent authority. The monitoring programmes, monitoring results as well as the emission/discharge and air quality/recipient monitoring reports are available to the public.

As the normal process emissions are nowadays reduced to a low level, the importance of the disturbance and exceptional emissions has increased. These emissions can be multiple compared to the normal emissions. The plants are obliged to report the amounts and durations of disturbance emissions. Reliable and adequate monitoring in exceptional conditions requires from the plant an effective information system, clear instructions, flexibility and high state of readiness.

In Finland there are monitoring data statistics on the waste water discharges, emissions into the air and waste management. The Regional Environment Centres run an emission/discharge datasystem over their own regions. The Finnish Environment Institute publishes summaries and reports and follows the general situation in the whole country using this data.

### **3.3 Self-monitoring and inspections**

The supervision policy in Finland is based on self-monitoring and checking of reports. When applying for a permit, the operators give a proposal for the monitoring programme to be approved by the authority. The authority can, if needed, make alterations to the programme. Also later on, alterations can be made to the monitoring programme according to the relevant needs. The plants are obliged to comply with the accepted monitoring programme. The larger plants carry out the measurements themselves or using a consultant. During unannounced inspections the authorities check different parts of the self-monitoring system to ensure that monitoring is carried out in an appropriate way. Inspections are also initiated in cases of process failures or other temporary malfunctioning, which may affect the environment.

Every two or three years the laboratory of the Finnish Environment Institute carries out an intercalibration of the waste water discharge analytical methods used by the plants applying self-monitoring. If the plant uses a consultant to carry out the self-monitoring or a part of it, only consultants under official supervision of the Finnish Environment Institute are allowed to be used. Reference measurements for emissions into the air are also arranged throughout the country to check the reliability of the different measurements.

Regular control samples are also taken and analyzed, and the results compared to the self-monitoring results to ensure the correctness of the analyses. The reliability of the information production chain from sampling and measurements to reporting is checked by the authority to assure the quality of the results. Also the certified environmental management systems can help to confirm the reliability and competence of monitoring.

### **3.4 Operation monitoring**

Control of the process and process equipment has close connection to emission monitoring in inhibition of operational disturbances and essential changes in operation, where immediate measures are needed to correct the situation. As operation control is an inner concern of the plants, authorities give no rules for it.

- Raw material and fuel monitoring is part of the operation control as their quality and composition essentially affects emissions.
- Good maintenance of process apparatus secures disturbance free operation.
- Monitoring of the condition and operation of the equipment used in pollution prevention is an important way to reduce emissions, to notice the need to repair malfunctions and for planning of improvements.
- Bookkeeping of disturbances is included in operation monitoring. Deviations from the normal situations (disturbances in process, defaults of purification equipment) have to be recorded and the authority has to be informed immediately.
- Education and motivation for monitoring ensures good practical work-out.

### **3.5 Integrated monitoring, a multi-media approach**

Multi-media control of pollutants from the pulp and paper industry has been identified as an urgent task in Finland. The current legislation reform, in which the wastewater, air and waste permits as well as noise abatement are combined, requires an integrated monitoring and control system.

A project on integrated monitoring of industrial emissions and their effects on the environment is currently carried out at the Finnish Environment Institute. Its objective is to integrate the monitoring programmes for different media (air, water, soil) and their environmental impacts. The objective is also to harmonize the monitoring practices throughout the country including sampling and measurements, calculations etc. to get more comparable and accurate data from the plants. Emphasis is put on the whole measurement chain starting from sampling, analyzing and calibration to reporting. One important aspect is to focus on relevant parameters in monitoring of emissions and their impacts to be able to assess the correlation between the emissions and their impacts on the environment properly and more cost effectively.

### **3.6 Harmonization and quality assurance**

It is most important to notice that great care has to be taken when comparing discharge and emission figures from different countries. Variations in the methods of sampling, pre-treatment and analysis of the sample, calculational and reporting practices make it difficult to compare the values correctly. Comparable monitoring data ought to be the basis when reviewing the compliance of national requirements or international agreements. The need for harmonization and quality assurance is urgent and plays an important role in international reporting of emissions, according to HELCOM, OSPARCOM and EU agreements among others.

Harmonization of measurements concerns determination of the different procedures used and the actual measurement methods, sampling, pretreatment of the sample, analysis and calibration practices as well as calculation and reporting of the emissions.

Until now there have been no official requirements for quality assurance, nor an acceptable limit for the total uncertainty of the emission measurements. A working group under the Ministry of the Environment is preparing a proposal on the uniform quality assurance requirements for the environmental laboratories. In the calculation of the emissions per time or production unit, many factors, in addition to concentration, are needed. Thus the uncertainty of the emission grows bigger than the uncertainty of the concentration. Also a project for certifying persons who carry out measurements is going on at the Finnish Environment Institute.

Standardization of the measurement methods is a tool for harmonizing the emission measurement practices. However, there is a variety of international and national standards. The measurement and calibration results should be retrieved to international measurement standards. The quality assurance of the national emission measurements varies from one EU country to another. In the recently published standards, methods for controlling the measurement quality (reference measurements, quality systems, certification/accreditation) are, however, presented.

Voluntary environmental management systems usually require a more extensive measurement and reporting system than the monitoring determined in the environmental permits.

## 4 Emission Monitoring System in Finland

Technical monitoring methods with notes on general lines are presented in parts II, III and IV of this report. Closer descriptions of the techniques are available at request.

### 4.1 Emissions into the air

Monitoring of the emissions into the air is based on the decision given by the Regional Environment Centre. The plants are required to give monitoring and reporting plans as well as plans for measures under disturbance and exceptional conditions. The operator's proposal for an emission monitoring system (**monitoring plan**) is presented to the permitting authority when applying for an air permit. Other parties, citizens as well as environmental NGO's can make remarks about it. In addition, the plants have to secure that the emissions are as low as possible.

The extent of emission monitoring depends on the impurities, amount and quality of the emissions, character of the emission sources, the extent of the air pollution prevention activities and the impact of the plant's emissions to the local air quality.

The authority can change the permit decision if the circumstances have significantly changed since the permit was granted or if the grounds for the permit have later proved to be different from those required when the permit was granted. The operator can be enjoined to give a clarification of the emissions and air pollution prevention measures and their impacts on the air quality. The authority can also, if needed, make alterations to the monitoring plan that the operator has suggested or give orders on the contents of the monitoring programme in cases where the operator has not presented one, or in cases where a programme is not feasible.

The **monitoring programme** approved by the permitting authority includes the following issues:

- which methods and type of equipment are used;
- how the monitoring is carried out;
- which emission sources shall be monitored;
- which parameters shall be measured;
- how the different emissions shall be measured (i.e. continuous measurement or, in case of separate measurements, how often the measurements shall be performed);
- (usually also) measurements of the characteristic of raw material or fuel,
- a summary of the most important disturbances in the process and in the purification method, and other possible changes that have influenced emissions into the air, and;
- in which way and how often the emissions should be reported and what the reports should include (emissions from separate emission sources are reported separately).

The results of the emission monitoring are reported to the supervisory authority in an **annual report**. Reports for shorter time periods are demanded now and then. There are no general rules according to which the reports should be drawn up but the content is given in the air permit. An annual report should include emissions from each emission source, methods for determination of the emissions and reliability of the methods as well as measures to maintain their reliability. The annual report also includes emissions under exceptional conditions (possible disturbance or accidental emissions), duration and number of the exceptional conditions as well as information on how the emission and disturbance time limits and target limits have been

met during the year. It is a rule that each significant disturbance or accidental discharge is immediately reported to the authority.

The Ministry of the Environment has given guidelines for monitoring of emissions into the air for the supervisory authority and operators in order to increase reliability, representativeness and comparability of the monitoring methods. The emission measurement results cannot be guaranteed to be reliable without a quality secured management. Also the competence for carrying out the technical measurements can vary. There are guidelines for quality secured emission management (see reference number 2).

## **Monitoring of air quality**

As a rule, the operators are obliged to participate in the local air quality monitoring in the area, usually carried out by the municipality or group of municipalities. The operators have to be well enough aware of the impact of the operation on the local air quality. The competent authority can give special orders on the arrangement of monitoring of emissions and their impacts. The local and regional aspects that affect the air quality (i.e. the quality, amount, variation and location of the emissions; the background concentration; population and nature being exposed to the impurities) determine the width of the follow-up.

A primary report of the local air quality covers the need for a municipality with neither substantial emissions nor heavy traffic. If there are substantial air polluting activities or heavy traffic in the municipality region, a basic report is done for evaluating the need for regular air quality monitoring. Direct monitoring methods (such as air quality measurements and distribution reports) or indirect methods (such as measuring the concentrations and impacts caused by the emissions in the environment) are used and the measurements carried out according to standardized methods.

## **4.2 Wastewater discharges**

The statutory monitoring of the emissions and their effects on the environment is based on Water Court's decision. The monitoring is accomplished according to a programme approved by the Regional Environment Centre. In the permit condition an industrial plant is ordered to make a proposal on a monitoring programme to the Regional Environment Centre within a given time, usually from one to three months. The authority may require amendments before approving the monitoring programme. The programmes can also be amended later on without a new permit procedure. If the plant and the authority cannot agree on the programme or amendments, the Water Court will give a final decision.

The monitoring obligation includes:

### **Internal operation monitoring**

- the quantity and quality of waste waters from different parts of the process
- the treatment plant performance and efficiency

### **External discharge monitoring**

- the quantity and quality of waste water discharged, concerns both process wastewater and other discharge sources like waters from storage and yard areas, cooling water etc.

### **Monitoring of the effects on the recipient**

- effects on the water quality
- effects on the biota.

The guidelines for monitoring programmes stress a case-by-case approach. Factors to be taken into account include the quantity and quality of discharges and their variations, treatment objectives, toxicity and effects in the recipient. The objective of statutory recipient monitoring is to provide information on the effects of effluents or other disturbing factors with the evaluation of spatial extent, temporal variation and the severity of these effects.

The results of the monitoring must be reported to the supervising authorities (Regional Environment Centres). Violation of limit values must be reported immediately. Also other exceptional incidents and discharges must be reported even if numerical limit values are not violated. There can also be other types of reporting obligations in the permits than reporting of monitoring results, e.g., use of chemicals or actions taken to prevent environmental accidents and exceptional loading. In case permit conditions include an obligation to make some studies or plans for future pollution abatement, study programmes are also approved by the Regional Environment Centre.

The permit does not prescribe who must or may take or analyze the samples. It is up to the plant to propose and to the authorities to approve whether self-monitoring or a consultant paid for by the plant is used to collect and analyze the samples and to report the results. In practise, pulp and paper industry usually carries out both internal operation monitoring and external discharge monitoring themselves.

The legal obligation to monitor the effects of the emissions on the recipient waters is based on the permits issued by the Water Court. Monitoring is carried out in practise by authorized environmental research laboratories (24 in the whole country). Whenever possible, the recipient monitoring of a pulp and paper plant is integrated with the monitoring of other polluting plants and municipalities discharging to the same recipient water area.

### **Monitoring programme for wastewater discharges**

The internal operation and external discharge monitoring programmes should be detailed and they should describe:

- sampling and flow measurement sites, methods and equipment
- maintenance and calibration of the sampling and flow measurement equipment
- storage and pretreatment of the samples
- analytical methods and laboratories
- data processing
- reporting

The discharge monitoring in pulp and paper mills includes typically about 10 or more parameters depending on the mill and type of production. In any case monitoring covers wider range of parameters than for which there are numerical limit values in the permit. Typically the monitoring programme also includes instructions for monitoring under exceptional situations.

The reporting period of the monitoring results for pulp and paper mills is once a month. The monthly production volume is reported as well. Furthermore, an annual report using a uniform format must be given, covering the entire calendar year. The plant also reports annually process internal and external investments in environmental protection and operating costs. The monitoring and cost data are annually collected to a publication "Industrial Wastewater Statistics" (in Finnish) by the Finnish Environment Institute.

## Monitoring programme for monitoring effects in recipient waters

The recipient monitoring programmes are designed according to guidelines given by the Finnish Environment Institute and the monitoring programmes for monitoring the effects for fisheries according to the guidelines published by the Finnish Game and Fisheries Research Institute.

The programmes for recipient monitoring describe, among other things:

- sampling sites
- sampling frequency, sampling periods, sampling depths
- chemical analyses
- sampling and analyse methods
- a plan for monitoring actions to be taken in case of exceptional situations, e.g. massive algal blooms or fish kills
- data processing and reporting
- the name of the authorized laboratory chosen to carry out the monitoring

The programmes for monitoring the effects on fisheries follow the above mentioned principles.

The recipient monitoring programmes for pulp and paper mills vary in some respects depending on the circumstances (hydrology, morphology etc.) in the recipient water body and on the quality of the wastewater discharges. Typically, the programmes include an annual water quality monitoring and a biological monitoring every third year. About 15-20 parameters such as oxygen concentration, oxygen demand, nutrients, suspended solids, and relevant harmful substances, are analysed in the water samples 4-6 times a year. Some programmes may include intensive sampling sites, which are sampled up to 20 times a year. The biological monitoring may include macroinvertebrate, plankton, periphyton or macrophyte investigations. In some cases, toxic substances are analysed from sediments or from the biota.

Water quality analysis results must be reported to the regional authorities within a month. The water quality data is recorded on the water quality data bank maintained by Finnish Environment Institute. Summarization with an assessment of the status of the recipient water body must be given annually to the authorities. The summarization shall include results from the water quality as well as from the biological and sediment monitoring.

Monitoring of fisheries may include fishery questionnaires, log books of fisheries, test fishing and measurements of off-flavours and harmful substances in fish. The results of fisheries monitoring are reported annually to the supervising authority (Ministry of Agriculture and Forestry).

### 4.3 Solid wastes

The Waste Act stipulates that the producer has to be aware of the wastes generated in the production, their environmental and health effects, of the possibilities to reduce the amount and harmfulness of the wastes, and of waste disposal. The producer has an obligation to develop the production towards a less waste generating process. The possessor of the waste has to be aware of the amount, quality, properties and origin of the waste possessed (i.e. general requirement for book-keeping), as well as of the environmental and health effects of the waste and of such properties that affect waste disposal. In the environmental permits there are provisions on the above mentioned issues for solid wastes.

Operators are required to keep book on wastes generated, collected, stored, transported, utilized or disposed as well as on wastes sold or transmitted. The amount, quality, properties and origin of the wastes must be recorded; also the delivery destinations and dates, transportation, utilization and disposal manners have to be recorded when the waste is delivered elsewhere from the place of generation.

Annually, the authorities have to be reported of the amount, disposal, utilization, storage or transportation of the wastes generated or obtained elsewhere. The report is drawn up on a special form using the EWC codes (European Waste Catalogue, 94/3/EC) for the wastes. Also the landfills have to give the annual report.

The Decision of the Council of the State on landfills contains provisions on landfill categories, general requirements for landfills, evaluation of suitability of wastes for landfilling, and on the monitoring of environmental effects of landfilling. As a result of this decision, the environmental permits for landfills that are in use in 2002, will also contain provisions on e.g. emissions into the air, noise immissions, as well as on the permeability of the bottomliner of the landfill. The decision also includes guidelines on frequency and place of sampling of landfill waters, surface and groundwaters. The landfill monitoring programme shall contain monitoring of the landfill waters and gas. The general bookkeeping requirement concerns also landfills. The landfill must be monitored so that the operator is able to give the annual report to the authorities on the following issues:

- a summary of expert evaluations of the suitability of the wastes for landfilling,
- information on the landfill area, volume, characteristics, settlement and hydrological conditions,
- a summary of the monitoring programme results,
- a report on the environmental impacts of the landfill and the environmental protection actions, and
- a report on exceptional events or departing from the monitoring programme accepted.

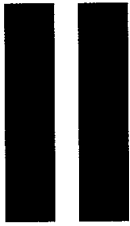
Before starting the operation of a new landfill or in case of extending the operation time of a landfill, a survey has to be carried out on the basic state of the surface and ground waters, gas generation and on the degradation state, to enable the assessment of the impacts of the landfilling later on.

#### **4.4 Noise immissions**

In the environmental permits it is required that the noise levels must not exceed certain noise immissions levels ( $L_{Aeq}$ ) which are set on basis of a Council of State Decision. These noise immission levels are set separately for residential and recreational areas in daytime (7.00 – 22.00) and in night time (22.00 – 7.00).

The operator of the plant has to give information of noise dissemination and structures built for noise abatement. The operator has to announce if the noise immission rises from the existing level.





# Emissions into the air

.....

## *1 Generation of Emissions into the Air and Emission Limits*

In the Finnish pulp and paper industry, an increase in the integration of pulp, paper and board production has taken place.

In pulp industry, emissions into the air originate both in the process and in energy production. Process emission sources are the recovery boiler, the lime kiln and the cooking department. Other emission sources are bleaching, washing, evaporation and manufacturing of pine oil. Emissions in the paper industry are mainly due to the flue gases from energy production. Energy production emission sources at a pulp and paper plant are the multifuel furnace, the bark and other solid fuel boilers. The number of emission sources is multiple in the old plants compared to the new ones.

Sulphure oxides (gaseous sulphure oxides counted as SO<sub>2</sub>): pproximately 40 per cent of the SO<sub>2</sub> emissions are process emissions, the rest comes from energy production. SO<sub>2</sub> is generated in the lime kiln when burning high concentration low volume gases (HCLV), in the recovery boiler and in bark and wood boilers.

At some plants SO<sub>2</sub> emission is predominant, while at other plants it is TRS emission. Diffuse sulphur emissions can be significant. It is necessary to carry out measurings that cover the whole plant in order to monitor the total sulphur emissions and to determine the most important emission sources or the compounds that dominate the total emissions. These results and a sulphur balance calculation are the basis for the decision where continuous measurements are necessary, where periodical measurements are valid, and which analyzer to choose.

Total reduced sulphure (TRS): The malodorous, noncondensable gases (NCG) in cooking of kraft contain H<sub>2</sub>S and reduced organic sulphure compounds (methyl mercaptane CH<sub>3</sub>SH, dimethyl sulphide (CH<sub>3</sub>)<sub>2</sub>S and dimethyl disulphide (CH<sub>3</sub>)<sub>2</sub>S<sub>2</sub>), the odour tresholds of which are very low. These compounds are easily evaporative and they are present in strong concentrations in some gases and condensates in the cooking and evaporation departments. Hydrogensulphide gas (H<sub>2</sub>S) can also be formed in incineration if there is shortage of oxygen in the combustion zone or when acids react with bisulphide ions in liquid phase. High concentration low volume gases (HCLV) origin in cooking, evaporation and condensate stripping, low concentration high volume gases (LCHV) in washing, heat treatment of black liquor and black liquor containers.

Nitrogen oxides (counted as NO<sub>x</sub>): One third of the pulp industry NO<sub>x</sub> emissions originates in the process (in the recovery boiler and the lime kiln) and the remaining two thirds come from energy production. Both the emissions from the recovery boiler and from the wood and bark boilers are low compared e.g. to the emissions from a coal boiler.

Chlorine compounds ( $\text{Cl}_2$ ,  $\text{ClO}_2$ ) are composed in preparation of bleaching chemicals. They are present in the removal vapours of the bleaching procedures.

Carbon monoxide (CO) and various amounts of persistent organic pollutants (POPs) and polyaromatic hydrocarbons (PAHs) are generated in an uncomplete burning process.

Carbon dioxide ( $\text{CO}_2$ ) is generated in the burning processes.

Particles: The chemical compounds in the flue and process gases are pursued to be returned to the process. Particles from the process consist mainly of  $\text{Na}_2\text{SO}_4$  or CaO and  $\text{Na}_2\text{CO}_3$ . Particles from the bark boilers and other energy production boilers are mainly in the form of ash which is removed from the process and which consists of inorganic material as well as of soot or unburned coke (depending on the fuel).

### **Emission limits**

The emission limits for separate emission sources are given as amount of emission per amount of product, or as concentration per produced energy/product unit, or as concentration per gas volume ( $\text{m}^3\text{n}$ ) often in certain oxygen or carbon dioxide concentration. The emission limits include also the percentage of operating time when the emissions should comply with the emission limits. Incidental disturbances are allowed to a certain extent.

Emission limits are given for sulphure oxides (gaseous sulphure oxides counted as  $\text{SO}_2$ ), total reduced sulphur (TRS), nitrogen oxides (counted as  $\text{NO}_2$ ), particles, carbon dioxide, chlorine, and for polychlorinated dibenzodioxines and dibenzofuranes for sludge burning boilers.

## **2 Control Technology**

Electric precipitators are used in the recovery of particles in the flue gases from the lime sludge and the bark boiler.

Scrubbers are used for washing out the gaseous compounds from the flue gases as follows:

|                                      |   |
|--------------------------------------|---|
| Flue gases from the recovery boiler  | → $\text{SO}_2$ removal and heat recovery |
| Flue gases from the lime kiln        | → Removal of particles                    |
| Burning of noncondensable flue gases | → $\text{SO}_2$ removal                   |
| Flue gases from the pine oil cookery | → Removal of $\text{H}_2\text{S}$         |
| Bleaching                            | → Removal of Cl and $\text{ClO}_2$        |

Collection and burning (also catalytic burning) of the gases, absorption, adsorption, biological methods and recovery of sulphure from the flue gases are used in handling of noncondensable gases.

## **3 Measurements**

### **3.1 Periodical measurements**

Periodical measurements are used for small and separate emission sources. When the volume flow is significant, as it is from the recovery boiler and lime kiln, continuous measurements are used. Periodical measurements are carried out as

manual single measurements or as short period continuous measurements by the plant itself or by an exterior measurer.

Periodical emission measurements are carried out annually for the following emission components: SO<sub>2</sub>, TRS, CO, CO<sub>2</sub>, NO<sub>x</sub>, Cl and particles, in some cases also for dioxine, HCl and furane emissions from sludge burning boilers according to the standards given in table 1. The first four components and particles are alternatively also measured continuously.

Periodical measurements give the state of emissions over the chosen sampling time. Quantities needed in every emission calculation, such as volume flow, oxygen content and humidity of the fume, are determined by periodical measurements. Periodical measurement results are also used as a support for calculating the continuous concentration measurement results into annual emissions.

To give reliable measurement results, maximum deviation and the number of measurements as well as relations between successive measurements should be determined. If the total emissions are counted on basis of one or two results, they represent poorly the real situation. When the cycles are known, the total emissions can be counted with help of a duration curve. The processes are not, however, steady. Varying driving means, prevailing process conditions, disturbances in processes etc. affect repeatedly the emissions.

### **3.2 Continuous measurements**

General requirements for continuous monitoring systems are that the sampling places should be representative and that the monitoring equipment should be suitable for the concentrations to be monitored and for the prevailing circumstances. The emission monitoring data system should preferably be part of the process control system. The availability of monitoring time is regarded sufficient when the continuous emission monitoring is operative at least 90 % of the annual operating time. A special problem is that even though the measurement system seems to operate faultless it may measure false concentrations. Therefore it is difficult to know the real availability of the system.

Measurement equipment for continuous measurements are fast installed. The results describe the temporal variations of the concentrations of the emission components during the operation.

Sulphure dioxide, TRS, particles and carbon oxides are generally measured continuously. Continuous measurements are carried out for emissions from the recovery boiler, the lime kiln, the handling system for noncondensable gases and the energy production boilers. Continuous NO<sub>x</sub> emission measurements are required for new recovery boilers and big bark boilers. As there is no reliable continuous measurement system for flue gas volume flow at present, there are certain difficulties in making the periodical values to describe the varying process situations.

Table 1. Finnish standards for periodical emission measurements

|   |   |
|---|---|
| SFS 3866  | Air quality. Stationary source emission. Determination of particulate emissions, manual method. 1990-12-21. 2nd ed. 13 p.   |
| SFS 3869  | Air quality. Stationary source emission. Determination of gaseous emissions. 1982-04-05. 1 ed. 21 p.  |
| SFS 5265  | Air quality. Stationary source emission. Determination of the mass concentration of sulphure dioxide by Thorin method. 1987-01-26. 1 ed. 6.p.   |
| SFS 5293  | Air quality. Stationary source emission. Determination of the mass concentration of hydrogen sulphide by iodometric titration method. 1987-02-23. 1 ed. 5 p.  |
| SFS 5412  | Air quality. Stationary source emission. Combustible flue gases. Determination of carbon monoxide by nondispersive infrared absorption. 1987-12-07. 1 ed. 9 p.  |
| SFS 5624  | Air quality. Stationary source emission. Determination of the flue gas state. 1990-06-04. 1 ed. 10 p.   |
| SFS 5625  | Air quality. Stationary source emission. Installing of access ports in the ducts. 1990-08-22. 1 ed. 6 p.  |
| SFS 5627  | Air quality. Stationary source emission. Determination of the mass concentration of the total reduced sulphure by liquid absorption techniques. 1990-06-25. 1 p. 3 s.   |
| SFS 5789  | Air quality. Stationary source emission. Determination of the mass concentration of inorganic fluorine by ion specific electrode. 1994-09-19. 1 ed. 5 p.  |
| SFS-EN 1948-1<br>put into force<br>with the endor-<br>sement standard<br>SFS 5683 | Stationary source emissions. Determination of mass concentration of PCDDs/PCDFs. 1997-02-10.<br>Part 1: Sampling. 74 p.<br>Part 2: Extraction and clean-up. 44 p.<br>Part 3: Identification and quantification. 54 p. |

### 3.3 Sampling, analysis and calculation

Sampling and sample treatment are usually the weakest points of the measurements. Because of the water content, solid particles and aggressive substances in the flue gases, problems can occur in taking a representative gas sample. Instructions for sampling are presented e.g. in the Finnish standards SFS 3869 and SFS 5624. Instructions for choosing of the measurement point are presented in SFS 3866.

The analyses are usually carried out according to SFS standards (based on the related international or foreign standards, see table 1) or type proved measurement equipment. ISO/TV 158 (Analysis of gases) and American Society for Testing and Materials have, for instance, published several standards and standard proposals for calibration.

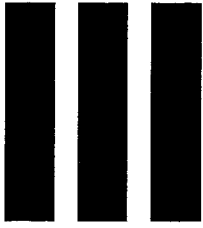
Emission calculation: Material balance calculations are used to complete emission measurements in order to get an impression of the reliability of the measurement results as well as to create a general view of the total emission level of each component. The amount of diffuse emissions that cannot be recorded by emission measurements can be substantial.

Material balance calculations are also used to examine the effects of emission reduction on the material balances of the plant. A material balance calculation gives an impression of the magnitude of the emission of a specific substance but cannot show accurate emission amounts, nor their division between emissions into the air, water discharges or solid wastes. Material balance calculations are often based on evaluated process flows and concentrations. Basic information is measured and the errors accumulate in the final results. Calculating of a reliable average emission level for a plant means long term monitoring of the processes and statistical examination. Calculation of the specific emissions is presented in SFS 5624.

### 3.4 Factors influencing a successful emission measurement

Each of the following factors has a remarkable influence on a successful measurement:

1. The measurer has to be competent and experienced. The laboratory needs a quality system and method instructions which ensure comparable performances between different persons carrying out the measurements. The competence of the measurements can be verified according to EN 45001 and ISO/IEC Guide 25.
2. The measurement equipment has to be suitable for the purpose, i.e. functioning in the relevant measurement area should be faultless (principle “the right equipment for the right place”). Calibrations, tightness of the sampling line, operation values for the equipment and their maintenance must be taken care of.
3. The measurement level must be suitable for the component. It is important to know if the gas is uniformly distributed at the level of the measurement. Flue gas flow at the measurement point should be turbulent and disturbance free, and there should be no leakages after the point. The gas velocity should be measured. In particle concentration measurements it is important to ensure the isokinetic properties and representativeness of sampling. It should be known whether the process is a batch process or a continuous one, and whether it is steady or variable. The duration of sampling must be chosen so that the result represents reasonably well emissions in different operational conditions.
4. The total effect of the uncertainty causing factors in the following list has to be recognized to be able to give reliable information of the measurement quality:
  - repeatability
  - linearity
  - drift of zero point
  - calibration
  - noise
  - dirtying / fouling
  - environmental conditions
  - disturbing components
  - humidity of the gas sample(Equipment suppliers often give repeatability, linearity, drift of the zero point and calibration for their equipment. )
5. The analysators must have regular maintenance.



# Wastewater Discharge Measurements

---

## *1 Wastewater Generation and Emission Limits*

In Finland the use or pollution of waters is not managed through norms and standards. Instead, there is a case-by-case deliberation about the impacts of the wastewater discharges on the use of the surface and ground water resources. The national target values for industrial discharges into waters were defined in the Decision of the Council of State on the water protection programme to 1995. The programme up to the year 2005 is approved and the implementation has started.

Discharges from kraft pulp manufacturing are generated in various processes from debarking of the wood to drying of the pulp. The main part of the wastewater flow originates from wood handling and bleaching. The rest of the wastewater flow consists of spills and condensates from different departments, temporary emissions from accidental overflows and also of some cooling waters from the power plant.

The amount of waste water flow in modern paper manufacturing depends mainly on the type of pulp used (chemical or integrated mechanical or both or DIP), on the degree of the water circulation closure on paper machine and also on the type of the end product. The wastewater flow originates from wood handling, mechanical pulping and as overflow from different parts of the paper machine process water circulation system.

The permits for wastewater discharges include i.a. conditions for emission limits and monitoring. It is up to the operator to choose the measures to meet the requirements. The discharge limit values for specific substances or parameters are mostly expressed as total amounts per unit time. In some cases the limit values are given as specific amounts per ton of product or as purification efficiencies. Limit values are set for  $COD_{Cr}/BOD_7$ , AOX, phosphorus and in some cases also for nitrogen. In addition, TSS limit values are set for some paper/board mills depending on the wastewater treatment.

## **2 Treatment**

The prevailing biological wastewater treatment method at kraft pulp mills is, due to the high efficiency and a well developed technology, treatment by an activated sludge plant (ASP).  $BOD_7$  removal is on the level of 95 % for both kraft pulp and paper mills, and  $COD_{Cr}$  removal on the level of 60 % for kraft pulp mills and 80 % for paper mills as average values.

There are other biological treatment plants, such as a few aerated lagoons and combinations of anaerobic filtration and aerated lagoon. So far, biological reactors based on suspended biofilm carriers are not used in external treatment. Some smaller paper mills have a combination of mechanical sedimentation and chemical precipitation.

## 3 Measurements

### 3.1 Parameters

Typical wastewater monitoring parameters to be analysed for pulp and paper mills are as follows:

- Waste water flow (Q)
- Total suspended solids (TSS)
- Temperature
- Chemical oxygen demand ( $COD_{Cr}$ )
- Biochemical oxygen demand ( $BOD_7$ )
- Total phosphorus (P)
- Total nitrogen (N)
- pH
- Conductivity
- AOX (only kraft pulp mills)

Also other parameters such as sulphur, sodium and heavy metals are monitored in some cases.

### 3.2 Flow measurement

Measuring of the total waste water flow is required in the waste water permits. There have been no provisions on the procedure or the accuracy of a flow measurement, but installation of automatic composite samplers (preferable flow dependent) are required as well as that the measurements have to be carried out in such a way that the results are reliable. Wastewater flow is usually measured with a venturi measurement equipment, but also magnetic and ultrasonic methods are used. Regular maintenance, monitoring and calibration are needed to obtain an acceptable measurement accuracy level.

The following calibration practices are used in pulp and paper discharge flow measurements:

- trace element measurements,
- velocity and area measurements,
- volume measurements and
- measurements with a reference meter

### 3.3 Sampling

Representative and properly performed sampling is essential for determination of wastewater discharges. There are general instructions for waste water sampling. However, the specific problems of pulp and paper waste water sampling, caused by the waste water quality variation due to productional reasons or functioning of the waste water treatment plant, have to be solved case-by-case.

Samples are either single samples, composite samples, or composite samples in proportion to the flow. A single sample reveals the composition of the wastewater at the sampling time. With several single samples it is possible to follow the waste water load peaks, quality variation and the easily variable parameters. A composite sample reveals the average composition over a chosen period. A 24 hour composite sample is normally taken in proportion to the flow so that the sampler is controlled by a flow meter.

Requirements for automatic sampling are:

- representative and suitable size samples,
- the sampler must not change sample composition,
- composite samples can be taken both by timing and in proportion to the flow,
- adequate margins for the sampling period are required,
- the equipment must be corrosion resistant, and
- the equipment must be easy to use and to maintain.

Sampling period and sample size are considered case-by-case depending on the analyses used and on the issues affecting the reliability of sampling and analyses. Samples for wastewater analysis are mostly taken over 24 hours, 5-7 days a week. In some cases samples are frozen and combined to cover a longer period. Samples for COD<sub>Cr</sub> and suspended solids determination are taken daily or continuously and analyzed daily. Samples for BOD<sub>7</sub> and nutrient determination are usually taken weekly. pH and conductivity are usually measured continuously.

### 3.4 Analyses

Every mill has a specific analysis programme. The programme usually covers wider a range of measurements and analyses than are required in the monitoring programme. The measurements and analyses are carried out according to the standards given in Table 2.

Factors affecting the analysis programme are e.g. production of the mill, quality variations of the waste water and research activities related to process technology, wastewater quality and biological treatment.

Table 2 Standards used for waste water discharge measurements and analyses

|                          |   |
|--------------------------|---|
| SFS-EN 872 <sup>1)</sup> | Water Quality. Determination of suspended solids. Method by filtration through glass fiber filters. 1996-08-26. 1ed. 16p.   |
| SFS-EN 27888             | Water Quality. Determination of electrical conductivity. 1994-05-09. 1ed. 12p.  |
| SFS 3021                 | Determination of pH value of water. 1979-02-12. 2nd ed. 4p.   |
| SFS 3019                 | Determination of Biochemical Oxygen Demand (BOD <sub>5</sub> ) of water. Dilution method. 1979-03-12. 1 ed. 9p.   |
| SFS 5504                 | Determination of Chemical Oxygen Demand. (COD <sub>Cr</sub> ) in water with the closed tube method. Oxidation with dichromate. 1988-08-22. 1ed. 4p.                         |
| SFS 3026                 | Determination of total phosphorus in water. Digestion with peroxodisulfate. 1986-02-24. 11p.  |
| SFS-EN 1189              | Water quality. Determination of phosphorus. Ammonium molybdate spectrometric method. 1997-08-25. 1ed. 31p.  |
| SFS 5505 I               | Determination of inorganic and organic nitrogen in waste water. Modified Kjeldahl method. 1988-08-22. 1ed. 4p.  |
| SFS-EN ISO 13395         | Water Quality. Determination of nitrite nitrogen and nitrate nitrogen and the sum of both by flow analysis (CFA and FIA) and spectrometric detection. 1997-01-07. 1ed. 28p. |
| SFS 3040                 | Determination of dissolved oxygen content in water. Titrimetric method. 1990-04-17. 2nd ed. 10p.  |
| SFS-EN 25814             | Water quality. Determination of dissolved oxygen. Electrochemical probe method. 1993-05-31. 1ed. 14p.   |
| SFS-EN 1485              | Water Quality. Determination of adsorbable organically bound halogens (AOX). 1997-03-10. 1ed. 20p.  |

1) Replaces SFS 3037



### 3.5 Calculation

Waste water discharges are calculated and reported according to the specifications determined in the monitoring programme approved by the Regional Environment Centre. Discharges are often calculated as below:

|                     |  |
|---------------------|--|
| Discharge per day   | The arithmetic mean value of the daily samples taken during one month divided by the number of sampling days |
| Discharge per month | Daily discharge multiplied by calendar days  |
| Discharge per year  | Sum of the values of monthly discharges  |

A typical waste water discharge monitoring report includes e.g. monthly mean values and variations for discharges in the points of monitoring before and after the treatment, limits values in force and also some production information.

### 3.6 Factors influencing on a successful emission measurement

The most significant factors influencing the whole measurement chain are flow measurement, sampling, pretreatment and storage of samples in the beginning of the whole measurement chain.

Reliability of flow measurement is the basis for monitoring of waste water discharges. The actual measurement accuracy in the real measurement circumstances is often poor compared with the accuracy the manufacturer has announced. A better accuracy and repeatability for the measurements could be reached by including a detailed report in the monitoring programme with a description of how the measurement, checkings, calibrations and maintenance are carried out. A flow measurement error of  $\pm 5\%$  has been recommended by a Finnish working group to be set for general target for all plants polluting natural waters.

Sampling and pretreatment of the sample play an important role in the reliability of the discharge results. Factors that influence on the representativeness of the samples and the results are as follows:

- Choice of sampling time and place: the sample must not be taken too close to the canal bottom or walls but at a place where the flow is turbulent.
- Sampling periods and volumes must be chosen sufficiently representative according to the analysis programme.
- The sample composition can be changed by abundance of solid matter.
- Defective function of the sampler or flow meter, which drives the sampler, results in a false result.
- A collection sample gathered by an automatic sampler has to be well mixed before analysis.
- Pretreatment of the sample must be carried out according to the analyzing programme.

There is a Finnish working group for sampling, the target of which is to guide and harmonize the assessment of sampling methods in accreditation. The accreditation of sampling methods is rather new and lot of problems are related to it. The basis for the work has been the general accreditation standard (ISO guide 25). Standards for sampling, pretreatment of samples and quality assurance have been produced by Committee ISO TC 147.

# IV

## Solid Wastes

---

### 1 Generation

In this report solid waste is defined as a material or an object that is removed from use and disposed. Bark and wood residues from wood handling are considered here as wastes only in cases they are permanently landfilled.

Usually the disposal of wastes consists of either incineration or landfilling. The elevating costs of landfilling and the low energy values in the wastes force the industry to seek also other options of utilization of the wastes. The obstacles for increased utilization are the huge amounts and the varying quality of the wastes generated as well as the content of some harmful compounds, e.g. cadmium, in the wastes.

The Finnish pulp and paper industry has landfills of its own. More than 90 % of solid process waste is transported to these landfills.

Sludge from the wastewater treatment is one of the main groups of solid waste. A large amount of sludge (1 – 2 % of production) is generated in the primary treatment of waste water. The primary sludge consists, depending on the type of production, of fibrous material, fillers and additives etc.

Biosludge is generated in the biological treatment of the wastewaters, chemical sludge when chemicals are used in the clarification and flocculation of waste waters. Other sludges containing a lot of sand and dirt are also produced in the debarking.

Various amounts of fly and furnace ashes are generated in the plants' energy production. The properties and the amounts of the ashes generated depend on the used fuel and furnace. More than half of the ashes are wood ashes. Other ash-like wastes are grits, dregs and limemud which are generated in the causticizing process at pulp plants.

Papermills generate various amounts of rejects, filler wastes and coating wastes etc. The amounts vary a lot from plant to plant depending on internal process measures.

Hazardous wastes, consisting mainly of solvents and oil, are mainly utilized in energy production, or taken to a hazardous waste treatment plant. Various amounts of scrap and construction wastes are also generated.

In Finland several projects are carried out on possibilities to advance utilization of wastes. The effect of an industrial landfill waste tax on efforts to minimize the amount of wastes is also under study.

### 2 Waste Management

Sludges have poor dewatering properties. Primary and biological sludges and bark are usually mixed before dewatering. Inorganic and/or organic chemicals are used to improve dewatering. Mixed sludge can be dewatered to 25 – 35 % of dry solids with belt filter presses which are commonly used. Dry solids content up to 40 – 50 % are reached with screw presses using steam in the pretreatment

stage. In Finland, dewatered sludge is mainly incinerated or landfilled (60 and 40 % respectively). One mill incinerates the dewatered bio sludge together with black liquor in the recovery boiler.

The energy content in these sludges is low and the use of auxiliary fuel is necessary in the incineration. Chemical sludges and paper mill sludges usually contain a lot of inorganics and landfilling is usually a more common option.

Ashes from energy production are usually wetted to avoid dust problems, and landfilled. Causticizing wastes are usually landfilled as well.

Some sludges have been composted and used as soil improving material and in landfill covers. A project is elaborated on the use of wood ash as fertilizer in the forest soil. The use of sludges and ashes as soil conditioner, fertilizer and for other agricultural use is restricted in various acts and decisions of the Council of State.

Sludges and ashes can also be utilized in road and landfill constructions as well as filler material in cement and concrete.

### **3 Measurements**

#### **3.1 Properties of solid wastes**

The properties of solid wastes that are generated, especially when they are utilized or taken to a landfill, have to be investigated. In addition to the requirements in the Waste Act on awareness on waste characteristics and properties, the Decision of the Council of State on landfills contains guidelines on testing of landfilling suitability of solid wastes.

The general principles in landfill approval are that the composition, leachability and long term behaviour and the properties of the waste have to be known. The approval of the landfilling of a waste for a certain landfill category is based on the origin and the properties of the waste. The evaluation of the properties of the waste is based on:

- the composition of the waste,
- the organic content and degradation properties of the waste,
- the content and leachability of harmful compounds, and
- the ecotoxicological effects of the waste and the landfill waters from the waste.

Evaluation of the suitability of landfilling of a waste is based on a three level procedure. The first step is, if considered necessary, a physical-chemical test of the short and long term behaviour of the leaching properties and rinsing out of the waste and harmful compounds. The permanency of the properties of the waste has after that to be verified regularly (ie. annually) with a more simple quality assurance test. The last step is the checking at the landfill that the properties of the waste correspond to the test results.

The suitability of a waste for landfilling is usually tested by expert laboratories specialized on leachate tests (i.e. the Technical Research Center of Finland). Analysis of the harmful compounds, e.g. heavy metals, depends on the wastes tested and on the varying solvents used. There is variation in the methods used for testing different wastes (i.e. which solvent is used). The suitability for landfilling depends also on the characteristics of the landfill, such as the quality of the construction and the stability of the landfill.

### **3.2 Monitoring of landfill gases**

The generation and flow of the landfill gas must be followed up (especially at landfills where easily degradable and gas producing organic waste is disposed) according to the monitoring programme approved by the competent authority. The amount, pressure and composition of the gas has to be determined at a given frequency. The gas recovery system must be checked regularly.

### **3.3 Monitoring of landfill waters, surface waters and ground waters**

Monitoring of landfill water, surface and ground waters is carried out according to a monitoring programme based on the requirements in the Decision of the Council of State on landfills and it has to be approved by the competent authority. The below described requirements don't concern all existing landfills (see Part I, Chapter 4.3), but the requirements will get more stringent as permits for landfills are renewed.

1. The amount and characteristics of the waste waters coming from the landfill (landfill waters) must be monitored at each point where waters are discharged. The flow and electric conductivity must be measured weekly. The characteristics of the waters must be measured four times a year during the use of the landfill. The parameters that are analyzed from the waters vary depending on the characteristics of the wastes landfilled. Sampling can be made more seldom if e.g. the quality of the water is stable.

2. The quality and flow of the surface waters have to be monitored with samples taken at least at two spots. One of the sampling spots has to be situated upstreams from the landfill. The other has to be situated in such a place that the effects of the landfill on surface waters are shown. After closing the landfill, samples have to be taken twice a year. Sampling frequency and place can be adjusted according to the properties of the landfill.

3. Ground waters have to be monitored at least at two spots downstreams and at least at one spot upstreams. At the impact area of the landfill on the quality of the water in the household wells has to be analyzed. The sampling details as well as the parameters to be analyzed in the groundwaters are decided case by case depending on the assumed quality of the landfill waters and groundwaters in the area. It also depends on the flow of the groundwater. A possible change in the quality of the ground waters has to be noticed as quickly as possible.

Parameters to be analyzed from the above mentioned waters are for example:

- temperature
- oxygen
- conductivity
- pH
- colour
- turbidity
- COD
- Tot-N
- NH<sub>4</sub>-N
- Tot-P
- Fe
- Cl<sup>-</sup>
- SO<sub>4</sub>
- Sulphide
- S
- Ca
- AOX
- Heavy metals

In addition, the authorities can demand intensified monitoring of other harmful compounds as organochlorides, for example, after landfilling has started at a new site. The height of the water level in groundwaters and the landfill has to be measured regularly. The analyses for landfill waters are carried out in the same way as for other wastewater analyses. The standards, laboratories etc. used are the same.

# References

- Atmospheric Emissions in Pulp and Paper Industry. 1992. Finnish Forest Industries Federation. (In Finnish)
- Aunela-Tapola L., Jormanainen P. et al. 1996. Quality assurance of the emission measurements. Uncertainty factors in determination of emissions. Technical Research Center 1799. 65 p. (In Finnish)
- Emission Monitoring in the Nordic Countries - control of point sources and river loading. 1995. TemaNord 519. (In Swedish)
- Enckell, E. 1994. OECD "BAT/EQO/IPPC" Review, Preliminary report submitted by Finland.
- The Finnish Background Report for the EC Documentation of Best Available Techniques for Pulp and Paper Industry. 1997. Ministry of the Environment. The Finnish Environment Publications 96. 144 p.
- Flow measurement in wastewater discharge monitoring. 1990. Swedish Environmental Protection Agency, General Guidelines 902. (In Swedish)
- Forsius, K. 1997. Monitoring of Emissions in Pulp and Paper Industry. Manuscript. (In Finnish)
- Guidelines for air quality measurements and for comparing the measurement results with the guideline values. 1986. The Ministry of the Environment, Series B 15. (In Finnish)
- Guidelines for monitoring of air quality. 1989. The Ministry of the Environment, Series B 17. (In Finnish)
- Guidelines for monitoring of emissions into the air. 1989. The Ministry of the Environment B 1989:17. (In Finnish)
- Haaramo, H. and Itkonen, J. (1994) Flow measurement of waste and other waters in industry and fisheries. Publications of the Water and Environment Administration 520. (In Finnish)
- Karhu, E. 1995. The Self-Control System in Finland. Report for the IMPEL Working Group III 14.-15.3.1995.
- Käyhkö R. and Penttinen J. 1997. Suitability of the continuous measurement systems in pulp and paper industry emission measurements. Publications of the Regional Environment Centers 39. South East Environment Center. 78 p. (In Finnish)
- Marjanen, J. 1995. Environmental emission data – international comparability. Study upon the need for international harmonization of the relevant determination procedures. Publications of the Water and Environment Administration, Series A 221
- Mäkelä, A., Antikainen, S., Mäkinen, I., Kivinen, J. and Leppänen. T. 1989. Sampling Methods for Water Analysis. Publications of the Water and Environment Administration, Series B 10. (In Finnish)
- Mäkinen, T. National Environmental Legislation Description. Manuscript.
- Porttikivi, R. 1993. Administrative organizations of environmental protection in Finland. Presentation.
- Pulp Industry and Air Pollution Control. Emissions into the air from pulping processes, emission control technology and monitoring. 1992/1993. Finnish Forest Industries Federation. (In Finnish)
- Silvo, K. 1993. Water Pollution Control in Finland. 1st International Conference on the "Environment Protection Strategy, Standardization and Control of Pollution Load on the Marine Environment", Tallinn, Estonia 20.-24.9.1993.
- Vuoristo, H. 1991. General Guidelines for Obligatory Control. Publications of the Water and Environment Administration, Control Guideline 26. (In Finnish)
- Vuoristo, H. And Ruoppa, M. 1997. Water and Fisheries Monitoring in Pulp and Paper Industry. Mimiograph Series of Finnish Environment Institute 94. (In Finnish)

# Documentation page

|  |   |  |
|--|---|--|
| Publisher  | Finnish Environment Institute   | Date<br>June 1998  |
| Author(s)  | Kristina Saarinen, Timo Jouttijärvi, Kaj Forsius  |  |
| Title of publication                                   | Monitoring and Control Practices of Emissions in Pulp and Paper Industry in Finland   |  |
| Parts of publication/<br>other project<br>publications |   |  |
| Abstract   | <p>Integrated monitoring of pulp and paper industry emissions and their impacts has been under development in Finland recently. The purpose is to harmonize the practices from sampling to reporting in the whole country as well as to find relevant monitoring parameters. Harmonization and quality assurance of the monitoring results are needed to get comparable data for reviewing the compliance of both national requirements and international agreements.</p> <p>The Finnish environmental legislation requires the operator to be aware of the emissions and their impacts on the environment. The competent environmental authority gives provisions for the operation. The operator can choose the measures to comply with the provisions. The authority approves the monitoring plan, according to which the plants carry out the measurements themselves or using a consultant. The operators have to clarify the emission levels and their changes in normal operation and to inform the authorities of the methods used in monitoring. They also have to report how the information is produced. The monitoring programmes, monitoring results and reports are available to the public. During unannounced inspections the authorities check different parts of the self-monitoring system to ensure that the monitoring is carried out in an appropriate way.</p> |  |
| Keywords   | emission monitoring, pulp and paper industry  |  |
| Publication series<br>and number                       | The Finnish Environment 220   |  |
| Theme of publication                                   |   |  |
| Project name and<br>number, if any                     |   |  |
| Financier/<br>commissioner                             |   |  |
| Project organization                                   |   |  |
|  | ISSN<br>1238-7312   | ISBN<br>952-11-0308-6                                      |
|  | No. of pages<br>32  | Language<br>English  |
|  | Restrictions<br>for public use  | Price<br>50 FIM  |
| For sale at/<br>distributor                            | Finnish Environment Institute<br>customer service e-mail: <a href="mailto:neuvonta.syke@vyh.fi">neuvonta.syke@vyh.fi</a><br>tel. 0358 9 40300100, telefax +358 9 40300190   | Edita Ltd, tel. + 358 9 566 022<br>telefax +358 9 566 0380 |
| Financier<br>of publication                            | Finnish Environment Institute   |  |
| Printing place and year                                | Edita Ltd, Helsinki 1998  |  |

# Kuvailulehti

|  |  |   |
|--|--|---|
| Julkaisija   | Suomen ympäristökeskus   | Julkaisu-aika<br>kesäkuu 1998   |
| Tekijä(t)  | Kristina Saarinen, Timo Jouttijärvi, Kaj Forsius   |   |
| Julkaisun nimi   | Suomen massa- ja paperiteollisuuden päästötarkkailu- ja valvontakäytäntö   |   |
| Julkaisun osat/<br>muut saman projektin<br>tuottamat julkaisut |  |   |
| Tiivistelmä  | <p>Massa- ja paperiteollisuuden päästöjen ja niiden vaikutusten yhtenäistä tarkkailua on kehitetty Suomessa viime aikoina. Tavoitteena on yhtenäistää menetelmät koko maassa näyteenotosta raportointiin saakka sekä löytää tarkoituksenmukaisia tarkkailuparametreja. Päästöjen mittausmenetelmien harmonisointiin ja tulosten laadunvarmistukseen on tarvetta, jotta kansallisten vaatimusten ja kansainvälisten sopimusten täyttämisen seuraamista varten olisi käytettävissä vertailukelpoista tietoa.</p> <p>Suomen ympäristölainsäädäntö edellyttää toiminnanharjoittajan olevan selvillä päästöistään ja niiden vaikutuksista ympäristöön. Ympäristöviranomaiset asettavat toiminnalle tietyt lupaehdot. Toiminnanharjoittaja voi itse valita toimenpiteen, jolla kyseiset ehdot täytetään ja tarkkailla itse, tai käyttäen konsulttia, toimintansa päästöjä viranomaisen hyväksymän tarkkailusuunnitelman mukaisesti. Toiminnanharjoittajan on selvitettävä päästötonsa ja niiden vaihtelut, samoin käyttämänsä tarkkailumenetelmät sekä ilmoitettava miten tiedot on tuotettu. Tarkkailuohjelmat, tarkkailun tulokset ja raportit ovat julkisia. Viranomaiset tarkistavat ennalta ilmoittamattomilla käynneillään, että tarkkailu suoritetaan hyväksyttävästi ja käyvät läpi osia itsetarkkailusta.</p> |   |
| Asiasanat  | päästöjen tarkkailu, massa- ja paperiteollisuus  |   |
| Julkaisusarjan nimi<br>ja numero                               | Suomen ympäristö 220   |   |
| Julkaisun teema  |  |   |
| Projektihankkeen nimi<br>ja projektinnumero                    |  |   |
| Rahoittaja/<br>toimeksiantaja                                  |  |   |
| Projektiryhmään<br>kuuluvat organisaatiot                      |  |   |
|  | ISSN<br>1238-7312  | ISBN<br>952-11-0308-6   |
|  | Sivuja<br>32   | Kieli<br>englanti   |
|  | Luottamuksellisuus<br>julkinen   | Hinta<br>50 mk  |
| Julkaisun myynti/<br>jakaja                                    | Suomen ympäristökeskuksen asiakaspalvelu<br>sähköpostiosoite: neuvonta.syke@vyh.fi<br>faksi (09) 4030 0190, puh. (09) 4030 0100  | Oy Edita Ab<br>asiakaspalvelu puh. (09) 566 0266<br>faksi (09) 566 0380 |
| Julkaisun kustantaja   | Suomen ympäristökeskus   |   |
| Painopaikka ja -aika   | Oy Edita Ab, Helsinki 1998   |   |

# Presentationsblad

|  |  |  |
|--|--|--|
| Utgivare   | Finlands miljöcentral  | Datum<br>juni 1998   |
| Författare   | Kristina Saarinen, Timo Jouttijärvi, Kaj Forsius   |  |
| Publikationens titel   | Utsläppskontroll- och tillsynspraktik i massa- och pappersindustri i Finland   |  |
| Publikationens delar/<br>andra publikationer<br>inom samma projekt |  |  |
| Sammandrag   | <p>Integrering av utsläpps- miljöeffektkontroll i massa- och pappersindustrin har utvecklats i Finland under de senaste åren. Syftet är att harmonisera kontrollmetoderna från provtagning till rapportering i hela landet samt finna lämpliga kontrollparametrar. Harmonisering av mätning-metoder samt kvalitetskontroll behövs för att kunna kontrollera uppfyllning av både nationella krav och internationella avtal.</p> <p>Finlands miljölagstiftning förutsätter att verksamhetsidkaren är medveten om verksamhetens utsläpp och dess miljöeffekter. Miljömyndigheterna ställer tillståndsvillkor för verksamheten, och verksamhetsidkaren kan själv välja metoder för att uppfylla kraven. Utsläppen kontrolleras enligt det godkända kontrollprogrammet av anläggningen själv eller med hjälp av en konsult. Verksamhetsidkaren måste utreda både utsläppens nivå och variationer samt de kontroll-metoder som använts, och anmäla hur uppgifterna har inhämtats. Kontrollprogram, kontrollresultat och rapporter är offentliga. Under oanmälda inspektioner granskar myndigheterna att kontrollen utförs enligt föreskrifterna, och genomgår delar av egenkontrollen.</p> |  |
| Nyckelord  | utsläppskontroll, massa- och pappersindustri   |  |
| Publikationsserie<br>och nummer                                    | Finlands miljö 220   |  |
| Publikationens tema  |  |  |
| Projektets namn<br>och nummer                                      |  |  |
| Finansiär/<br>uppdragsgivare                                       |  |  |
| Organisationer<br>i projektgruppen                                 |  |  |
|  | ISSN<br>1238-7312  | ISBN<br>952-11-0308-6                                      |
|  | Sidantal<br>32   | Språk<br>engelska  |
|  | Offentlighet<br>offentlig  | Pris<br>50 mk  |
| Beställningar/<br>distribution                                     | Finlands miljöcentral<br>kundservice e-mail: neuvonta.syke@vyh.fi<br>telefax (09) 4030 0190, tel (09) 4030 0100  | Oy Edita Ab<br>tel. (09) 566 0266<br>telefax (09) 566 0380 |
| Förläggare   | Finlands miljöcentral  |  |
| Tryckeri/<br>tryckningsort och -år                                 | Edita Ab, Helsingfors 1998   |  |



# Dokumentationsblatt

|   |   |   |
|---|---|---|
| Herausgeber   | Finnische Anstalt für Umweltforschung   | Erscheinungsdatum<br>Juni 1998                              |
| Autor(en)   | Kristina Saarinen, Timo Jouttijärvi, Kaj Forsius  |   |
| Titel   | Die Überwachungsverfahren der Emissionen und ihrer Umwelteinflüsse der Masse- und Papierindustrie in Finnland   |   |
| Teilpublikationen/<br>weitere Publikationen<br>des Projekts |   |   |
| Zusammenfassung   | <p>In den letzten Jahren ist in Finnland die integrierte Überwachung der Emissionen und ihrer Umwelteinflüsse im Bereich der Masse- und Papierindustrie mit dem Ziel weiterentwickelt worden, die angewendeten Überwachungsverfahren, von der Probenentnahme bis zur Berichterstattung, landesweit zu harmonisieren und geeignete Überwachungsparameter festzulegen. Sowohl auf nationaler als auf internationaler Ebene besteht Bedarf zur Harmonisierung der Meßverfahren und zu einer Qualitätskontrolle der Ergebnisse, um die Erfüllung nationaler Anforderungen und internationaler Vereinbarungen anhand vergleichbarer Daten verfolgen zu können.</p> <p>Die Finnische Umweltgesetzgebung verpflichtet die Abfallerzeuger, über ihre Emissionen und deren Umwelteinflüsse informiert zu sein. Die Umweltbehörden stellen bestimmte Anforderungen an den Betrieb von Unternehmen, stellen den Betreibern aber frei, mit welchen Mitteln diese Anforderungen erfüllt werden und ob die nach den von den Behörden genehmigten Überwachungsplänen durchzuführenden Messungen selbst vorgenommen oder beratenden Unternehmen übertragen werden. Die Betreiber sind verpflichtet, Bericht über ihre Emissionsniveaus und deren Schwankungsbereiche, die verwendeten Meßverfahren und die Erfassungsweise der Meßergebnisse zu erstatten. Das Überwachungsprogramm, die Meßergebnisse und die Berichte sind öffentlicher zu erhalten. Anhand vorher unangemeldeter Inspektionen kontrollieren die Behörden, daß die Überwachung in akzeptabler Weise durchgeführt wird und inspizieren Teile des Eigenüberwachungsprogramms.</p> |   |
| Schlüsselwörter   | Überwachung der Emissionen, die Masse- und Papierindustrie  |   |
| Name und Nummer der Serie                                   | Finnische Umwelt 220  |   |
| Art der Publikation   |   |   |
| Name und Nummer des Projekts                                |   |   |
| Finanzierung/<br>Auftraggeber                               |   |   |
| Am Projekt beteiligte Organisationen                        |   |   |
|   | ISSN<br>1238-7312   | ISBN<br>952-11-0308-6                                       |
|   | Seitenzahl<br>32  | Sprache<br>Englisch   |
|   | Vertraulichkeit<br>öffentlich   | Preis<br>50 FIM   |
| Vertrieb  | Finnische Anstalt für Umweltforschung<br>Kundendienst, email: neuvonta.syke@vyh.fi<br>tel. +358 9 4030 0100, telefax + 358 9 4030 0190  | Edita Ltd, tel. + 358 9 566 022<br>telefax + 358 9 566 0380 |
| Verleger  | Finnische Anstalt für Umweltforschung   |   |
| Verlegeort und -zeit  | Edita Ltd, Helsinki 1998  |   |

# Page de documentation

|  |  |   |           |
|--|--|---|-----------|
| Publieur   | Institut Finlandais de l'environnement   | Date  | 15.6.1998 |
| Auteur(s)  | Kristina Saarinen, Timo Jouttijärvi, Kaj Forsius   |   |           |
| Titre de publication                                       | Contrôle et surveillance des émissions de l'industrie de la pulpe et du papier en Finlande   |   |           |
| Parts de publication/<br>autres publications<br>de project |  |   |           |
| Abstract   | <p>En Finlande on a récemment développé du contrôle des émissions provenant de l'industrie de la pulpe et du papier et de leur impact sur l'environnement. Le but est d'harmoniser, à l'échelle nationale, les méthodes allant du prélèvement des échantillons jusqu'à leurs résultats; de trouver de nouveaux paramètres appropriés au contrôle. L'harmonisation des mesures d'émissions est nécessaire pour s'assurer de la qualité des résultats afin d'être en mesure de fournir des données comparables pour répondre aux exigences nationales et de pouvoir remplir les conditions requises par des conventions internationales.</p> <p>La législation finlandaise de l'environnement requiert de l'opérateur qu'elle sait du courant de ses émissions et de leur impact sur l'environnement. L'autorité environnementale compétente dresse les conditions de permis et l'opérateur peut décider des moyens de fonctionnement pour autant que les conditions soient remplies. L'opérateur s'occupe lui-même des mesures ou il fait appel à un consultant pour mesurer les émissions selon le programme de contrôle approuvé par l'autorité compétente. Les opérateurs ont l'obligation d'informer les autorités compétentes des émissions, de leur variations et des méthodes de contrôle. Les programmes de contrôle et leurs résultats sont du domaine public. Au cours d'inspections non annoncées l'autorité contrôle les différentes étapes du système de contrôle par l'opérateur ou le consultant et s'assure que le contrôle correspond bien au programme de contrôle.</p> |   |           |
| Mots clef  | contrôle des émissions, l'industrie de la pulpe et du papier   |   |           |
| Série et numéro de publication                             | L'environnement finlandaise 220  |   |           |
| Thème de publication                                       |  |   |           |
| Nome et numéro de publication                              |  |   |           |
| Creancier/<br>commissionnaire                              |  |   |           |
| Organisation de project                                    |  |   |           |
|  | ISSN<br>1238-7312  | ISBN<br>952-11-0308-6   |           |
|  | Nombre de pages<br>32  | Langue<br>Anglais   |           |
|  | Restrictions<br>public   | Prix<br>50 FIM  |           |
| Lieu de vente/<br>dispensieur                              | Institut Finlandais de l'environnement<br>Service de client, email: neuvonta.syke@vyh.fi<br>tel. 0358 9 40300100, telefax +358 9 40300190  | Edita Ltd, Edita Ltd, tel. + 358 9 566 022<br>telefax +358 9 566 0380 |           |
| Creancier de publication                                   | Institut Finlandais de l'environnement   |   |           |
| Lieu et année d'imprimerie                                 | Edita Ltd, Helsinki 1998   |   |           |

## Suomen ympäristö

1. Järvinen, Mika: Ympäristöystävä vai vapaamatkustaja? Suomen ympäristökeskus.
2. Saukkonen, Sari & Kenttämies, Kaarle (toim.): Metsätalouden vesistövaikutukset ja niiden torjunta. METVE-projektin loppuraportti. Suomen ympäristökeskus.
3. Kosola, Marjaleena; Miettinen, Pauli & Laikari, Hannu: Ympäristötalous - ajankohtaisia tutkimus- ja kehittämistehtäviä. Suomen ympäristökeskus.
4. Riihimäki, Juha; Yrjänä, Timo & van der Meer, Olli: Lyhytaikaisäädön elinympäristövaikutusten arviointimenetelmät. Suomen ympäristökeskus.
5. Blomster, Jaannika: Ravinnekuormituksen vaikutus rantavyöhykkeen leväyhteisöihin ja vaikutusten arvioinnissa käytetyt menetelmät. Suomen ympäristökeskus.
6. Soveri, Jouko & Peltonen Kimmo: Lumen ainepitoisuudet ja talviaikainen laskeuma Suomessa vuosina 1976–1993. Suomen ympäristökeskus.
7. Britschgi, Ritva: Pohjavesien suojelun ja kiviaineshuollon yhteensovittaminen – esiselvitys Vaasan seudulla. Suomen ympäristökeskus.
8. Hutka, Reijo; Laitinen, Timo; Holmberg, Maria; Maunula, Markku & Schultz, Titta: Happamien sulfaattimaiden ionivirtausmalli (HAPSU). Suomen ympäristökeskus.
9. Hagan, Harri: Lähiökorjaamisen arkkitehtoniset vaikutukset. Ympäristöministeriö.
10. Kylä-Setälä, Annamajja & Assmuth, Timo: Suomen maaperän tila, kuormitus ja suojelu. Suomen ympäristökeskus.
11. Hyvärinen, Pekka; Vehanen, Teppo; Tigunov, Sergei; Mäki-Petäys, Aki & Konttinen, Erja: Kalojen vaellus Inarijärvestä Paatsjokeen. Suomen ympäristökeskus.
12. Palveluasumistyöryhmä: Palveluasumistyöryhmän muistio. Ympäristöministeriö.
13. Lepistö, Liisa & Pietiläinen, Olli-Pekka: Kasviplanktonin määrän ja koostumuksen muutokset Lokassa, Porttipahdassa ja Kemijärvessä. Suomen ympäristökeskus.
14. Kaukoniemi, Tapani & Tikkanen, Hannu: Kulttuurimaiseman kasvot, Nivalan Kotila. Ympäristöministeriö.
15. Korhonen, Pekka & Virtanen, Markku: Elohopean kertymisen kuvaaminen matemaattisella mallilla – Arvio Kokemäenjoen keskiosan ruoppauksen vaikutuksesta vesistön elohopeatilanteeseen. Suomen ympäristökeskus.
16. Virkkala, Raimo: Metsien suojelualueverkon rakenne ja kehittämistarpeet – ekologinen lähestymistapa. Suomen ympäristökeskus.
17. Tana, Jukka & Lehtinen, Karl-Johan: The aquatic environmental impact of pulping and bleaching operations – an overview. Suomen ympäristökeskus.
18. Nippala, Eero & Jaakkonen, Liisa: Asuinkerrostalojen kuntoarviot. Ympäristöministeriö.
19. Karjalainen, Heli; Seppälä, Satu & Walls, Mari: Ammoniumtyypen merkitys kasviplanktonituotantoa säätelevänä tekijänä – esimerkkinä Kallavesi. Pohjois-Savon ympäristökeskus.
20. Lepistö, Liisa; Cronberg, Gertrud & Tikkanen, Toini: Records of some algal species, Nordic Phytoplankton Workshop 7–10.6.1994. Suomen ympäristökeskus.
21. Pesonen, Reijo: Vuorovaikutteista suunnittelua Jyväskylän Kekkolassa. Ympäristöministeriö.
22. Rouhiainen, Hanna: Rakentamisen ja kiinteistönmuodostuksen ohjaaminen haja-asutusalueilla Vertaileva selvitys haja-asutuksesta Suomessa, Ruotsissa, Norjassa, Tanskassa, Saksassa ja Englannissa. Ympäristöministeriö.
23. Heikkilä, Mikko; Karppinen, Seppo & Santasalo, Tuomas: Suomalaisia kävelykeskustoja. Ympäristöministeriö.
24. Kiviranta, Samuel, Summala, Mika & Hänninen Pekka: Työpaikka-alueiden käytön tehostaminen. Yhteenvetoraportti. Ympäristöministeriö.
25. Marttinen, Kari: Hallintosopimukset ympäristöpolitiikan ohjauskeinona. Ympäristöministeriö.
26. Hammar, Taina; Huovila, Juhani; Lahti, Erkki; Manninen, Pertti; Oksman, Heikki; Punju, Pirjo & Taipalinen, Irmeli: Pyydyksiä limoittavan *Hyalotheca dissiliens* -koristelevän runsastumisesta ja sen syistä. Pohjois-Savon ympäristökeskus.
27. 5th Annual Report 1996, UN ECE Convention on Long-Range Transboundary Air Pollution, International Co-operative Programme on Integrated Monitoring of Air Pollution Effects on Ecosystems. Suomen ympäristökeskus.
28. Sojakka, Pekka: Perifytonmenetelmien käyttökelpoisuus kalankasvatuksen vesistövaikutusten arvioinnissa. Etelä-Savon ympäristökeskus.
29. Kuusamotyöryhmä: Kuusamon yhteismetsän vanhojen metsien luonnonarvojen säilyttäminen ja yhteismetsän toiminnan turvaaminen. Ympäristöministeriö.
30. Vanhojen metsien suojelutyöryhmä: Vanhojen metsien suojelu Pohjois-Suomessa – Vanhojen metsien suojelutyöryhmän osamietintö III. Ympäristöministeriö.
31. Pirinen, Auli; Salminen, Markku; Speeti, Tero: Asuinkerrostalon huoltokirja esimerkikikohteeseen. Ympäristöministeriö.
32. Pirinen, Auli; Salminen, Markku; Speeti, Tero: Asuintalon huoltokirjan laadinta. Ympäristöministeriö.
33. Mukherjee, Arun B: The use and release of silver in Finland. Suomen ympäristökeskus.
34. Laine, Anne; Sutela, Tapio; Heikkinen, Kaisa; Karvonen, Keijo; Huhta, Arto; Muotka, Timo & Lappalainen, Antti: Turvetuotannon vaikutukset koskikaloihin ja niiden elinympäristöön. Pohjois-Pohjanmaan ympäristökeskus.
35. Savolainen, Mirja; Kaasinen, Aulis; Heikkinen, Kaisa; Ihme, Raimo; Kämä, Tarmo & Alasaarela, Erkki: Turvetuotannon vesiensuojeluvaihtoehtojen tapauskohtainen vertailu. Pohjois-Pohjanmaan ympäristökeskus.

36. Alanen, Jouni & Saastamoinen, Salla: Euroopan Unioniin tuotavat rakennustuotteet, vaatimusten mukaisuuden osoittaminen. Ympäristöministeriö.
37. Pohjois-Suomen vanhojen metsien suojelun kompensaatiotyöryhmän mietintö. Ympäristöministeriö.
38. Tanskanen, Juha-Heikki: Syntypaikkalajitteluun perustuvan yhdyskuntajätehuollon tarkastelu. -jätevirrat, kustannukset ja päätökset. Suomen ympäristökeskus.
39. Malaska, Pentti; Luukkanen, Jyrki; Vehmas, Jarmo & Kaivo-oja, Jari: Ympäristöperusteinen energiaverotus Pohjoismaisia vertailuja ja suomalaisen keskustelun arviointia. Ympäristöministeriö.
40. Illén, Pekka; Rautavuori, Leena & Salminen, Eero: Uukuniemen kirkonkylän kulttuurimaiseman hoitotuunnitelma. Ympäristöministeriö.
41. Ympäristöministeriö: Kaavoitustoimen seuranta. Ympäristöministeriö.
42. Outila, Tarja: Keivitsan kaivosohjelma – kaavoitusjärjestelmät ja luonnonsuojelu. Ympäristöministeriö.
43. Lankinen, Markku: Asuntorakentamisen ennakointi – Määrästä laatuun. Ympäristöministeriö.
44. Tanskanen, Heikki; Walls, Mari; Maripuu, Lea & Tuhkanen, Tuula: Otsonoinnin ja otsoni/vetyperoksidikäsittelyjen vaikutus metsäteollisuuden kuorimovesien ekotoksisuuteen. Pohjois-Savon ympäristökeskus.
45. Huttunen, Leena; Rönkä, Esa & Matinvesi, Jukka: Erilaisten viljely- ja lannoitustapojen vaikutus pohjaveden laatuun – lysisimetritutkimus karkealla hietamaalla. Suomen ympäristökeskus.
46. Paulus, Ilkka: Romaniväestön asuntotilanne 1990-luvun puolivälissä. Ympäristöministeriö.
47. Monitoimijainen lähiöuudistus. Lähiötyöryhmän loppuraportti ja toimenpide-ehdotukset. Ympäristöministeriö.
48. Tarkoma, Jari: Asumisoikeusasunnot- ja asukkaat. Tilastaselvitys vuosina 1992 ja 1993 valmistuneista asunnoista. Ympäristöministeriö.
49. Saarenheimo, Ulla & von Hertzen, Heikki, S: Asunnottomuus väheni Suomessa. Määrätietoinen työ tuo tuloksia. Ympäristöministeriö.
50. Myllymäki, Pauliina: Radonin ja uraanin poisto kalliopohjavedestä. Suomen ympäristökeskus.
51. Salo, Simo; Ekholm, Petri & Knuutila, Seppo : A comparison of methods for nutrient source apportionment in Nordic rivers. Suomen ympäristökeskus.
52. Paukkunen, Marika & Vartia, Pauli: Selvitys ympäristövaikutusten arviointimenettelyn kokemuksista 1994–95. Ympäristöministeriö.
53. Haimi, Jari & Salminen, Janne: Kemikaalien haittavaikutukset terrestrisessä ympäristössä – tutkimus- ja testimenetelmien kehittäminen erityisesti suomalaiselle maaperälle. Suomen ympäristökeskus.
54. Rintala, Jari: Soranottoalueiden jälkihoito – pintarakennemateriaalit suojaerhouskassa. Suomen ympäristökeskus.
55. Britschgi, Ritva & Gustafsson, Juhani (toim.): Suomen luokitellut pohjavesialueet. Suomen ympäristökeskus.
56. Heli Vuoksima: Lasipakkausten kierrätysjärjestelmät ja niiden kustannukset Suomessa - keräysjärjestelmien kustannustehokkuusvertailu. Ympäristöministeriö.
57. Nysten, Taina & Hänninen, Tuija: Tiesuolan pohjavesihaittojen vaikutuksista ja torjuntakeinoista. Suomen ympäristökeskus.
58. Marttunen, Mika; Hellsten, Seppo; Puro, Annukka; Huttula, Erkki; Nenonen, Marja-Leena, Järvinen, Erkki; Salonen, Erno; Palomäki, Risto; Huru, Helge & Bergman, Tarja: Inarijärven tila, käyttö ja niihin vaikuttavat tekijät. Lapin ympäristökeskus.
59. Kettunen, Aija: Kuntien ympäristöhallinnon asema ja tila; Faktaa ja käsityksiä. Ympäristöministeriö.
60. Uusien vuokrasuhteiden vuokrat. Tilastaselvitys vapaarahoitteisten vuokra-asuntojen uusista vuokrasuhteista huhtikuussa 1996. Ympäristöministeriö.
61. Pehkonen, Pertti & Jansson, Jonna: Viheralan tutkimus- ja kehittämistyö. Tilannekatsaus. Ympäristöministeriö.
62. Söderman, Lundsten, Leinonen & Grönholm: Valtakunnallisen yöperhosseurannan 3. vuosiraportti. 3 Nocturna Annual Newsletter 1995. Suomen ympäristökeskus.
63. Rosenström, Ulla; Lehtonen, Markku & Muurman, Jarmo: Trends in the Finnish Environment - Indicators for the 1997 OECD Environmental Performance Review of Finland. Ympäristöministeriö.
64. Haarni, Tuukka & Vartiainen, Perttu: Kaupunkiverkostoituminen Suomessa. Ympäristöministeriö.
65. Nyman; Halmetoja; Pohtamaa ym: M/S Eiran öljyvahingon pitkäaikaisvaikutukset Merenkurkussa. Länsi-Suomen ympäristökeskus.
66. Sinisalmi, Tuomo (toim.): Vesivoimalaitosten lyhytaikaisäädön vaikutustutkimukset. Pohjois-Pohjanmaan ympäristökeskus.
67. Kananaja, Tapio: Kymen läänin kallioperän suojelu- ja opetuskohteita. Ympäristöministeriö.
68. Keppo, Eeva: Vaasan läänin kulttuuriympäristöohjelma.
69. Hyvärinen, Veli (toim.): Hydrologinen vuosikirja 1993. Hydrological yearbook 1993. Suomen ympäristökeskus.
70. Savolainen, Matti: Omakotitalojen kustannuslaskentajärjestelmä. Ympäristöministeriö.
71. Nysten, Taina; Suokko, Tuulikki & Tarvainen, Timo: Ympäristögeologian sovelluksia GTK – SYKE ympäristötutkimusseminaari 1.10.1996. Suomen ympäristökeskus.
72. Kemppainen, Eija: Suomen uhanalaiset lajit. Ketonukki (*Androsace septentrionalis*). Suomen ympäristökeskus.
73. Halonen, Pekka; Tuukki, Eeva; Puolasmaa, Arto & Kaipainen, Heidi: Suomen uhanalaisia lajeja: Pohjanhyttelöjäkälä (*Collema curtisporum*) Lännehyytelöjäkälä (*Collema nigrescens*) Risahyytelöjäkälä (*Collema multipartitum*). Suomen ympäristökeskus.
74. Kemppainen, Eija & Karling, Marita: Suomen uhanalaisia lajeja: Koirankieli (*Cynoglossum officinale*). Suomen ympäristökeskus.
75. Kosonen, Lasse; Kaipainen, Heidi & Kemppainen, Eija: Suomen uhanalaiset lajit Mäkiorkvokka (*Viola collina*). Suomen ympäristökeskus.

76. Pykälä, Juha & Vuorinen Soili: Suomen uhanalaiset lajit. Punavalkku (*Cephalanthera rubra*). Suomen ympäristökeskus.
77. Pykälä, Juha & Vuorinen Soili: Suomen uhanalaisia lajeja: Vuorikuisma (*Hypericum montanum*). Suomen ympäristökeskus.
78. Kaipainen, Heidi; Kemppainen, Eija & Bonn; Thomas: Suomen uhanalaisia lajeja: Tähtähelmikkä (*Melica ciliata*). Hotade arter i Finland: Grusslok (*Melica ciliata*). Suomen ympäristökeskus.
79. Joensuu, Ilona; Vuori, Kari-Matti & Nieminen, Mari: Vesistöarakentamisen ja lyhytaikaissäännöstelyn vaikutus Perhonjoen koskien eliöyhteisöihin. Keski-Pohjanmaan ympäristökeskus.
80. Hassi, Laura: Ihanteita ja ohjausvälineitä - asumisen tuen kohdentuminen vuonna 1993. Ympäristöministeriö.
81. Grönroos, Juha; Rekolainen, Seppo & Nikander, Antero: Maatalouden ympäristötuen toimenpiteiden toteutuminen v. 1995. Suomen ympäristökeskus.
82. Leskelä, Ari & Hudd, Richard: Kyrönjoen lohi- ja meritaimenistutusten tulokellisuus Carlin-merkin-töjen perusteella. Länsi-Suomen ympäristökeskus.
83. Hudd, Richard; Kjellman, Jakob & Leskelä, Ari: Kyrönjoen suiston poikastuotanto ja kalakannat. Länsi-Suomen ympäristökeskus.
84. Markat ja maankäyttö. Kaavatalouden näkökohtia päättäjille. Ympäristöministeriö.
85. Uuskallio, Irma: National overview on distressed urban areas in Finland. Ympäristöministeriö.
86. Peltola, Taru: Yritysten muuttuva toimintaympäristö hallinnon haasteena. Hämeen ympäristökeskuk-sen pk-yritysprojektin loppuraportti. Hämeen ympäristökeskus.
87. Luostarinen, Matti; Yli-Viikari, Anja (toim.): Maaseudun kulttuurimaisemat. Suomen ympäristökeskus, Maatalouden tutkimuskeskus.
88. Airamo, Raimo & Permanto, Timo: Yleiskaavoitus ja vaikutusten arviointi. Esimerkkinä Lahden yleis-kaavoitus 1946 - 1996. Ympäristöministeriö.
89. Seppälä, Jyri & Jouttijärvi, Timo (toim.): Metsäteollisuus ja ympäristö. Suomen ympäristökeskus.
90. Jokioisten kulttuuriympäristöohjelma. Ympäristöministeriö.
91. Kilpailuttaminen valtion tukemassa asuntotuotannossa. Työryhmän mietintö. Ympäristöministeriö.
92. Malaska, Pentti; Luukkanen, Jyrki; Vehmas, Jarmo & Kaivo-oja, Jari: Environment – Based Energy Taxation in the Nordic Countries. Comparisons by Energy Source and a Review of the Finnish Discussion. Ympäristöministeriö.
93. Muuttuva ihminen – muuttuva asunto. Ympäristöministeriö.
94. Jauhiainen, Tapani; Vuorinen, Heikki; Heinonen-Guzejev, Marja & Paikkala, Sirkka-Liisa: Ympäristö-melun vaikutukset. Ympäristöministeriö.
95. Lind, Tuula & Pietala, Jorma: Kotipalveluja käyttävien vanhusten kauppatkat Lahdessa. Ympäris-töministeriö.
96. The Finnish Background Report for the EC Documentation of Best Available Techniques for Pulp and Paper Industry. Ympäristöministeriö.
97. Alanen, Tommi & Ratia, Pasi: Asuntorakentamisen työllisyysvaikutukset. Ympäristöministeriö.
98. Pitkäjärvi, Jyrki: Geenitekniikalla muunnettujen mikro-organismien ympäristövaikutukset. Suomen ympäristökeskus.
99. Viinikainen, Tytti: Yhteiskuntatieteellinen ympäristötutkimus Suomessa. Katsaus tutkimusaloihin ja kirjallisuuteen. Suomen ympäristökeskus.
100. Pietiläinen, Olli-Pekka & Pirinen, Marja: Typpi- ja fosforikuormituksen vaikutus perifytonon kas-vuun Kymijoenla. Suomen ympäristökeskus.
101. Maataloudesta peräisin olevien nitraattien vesiin pääsyn rajoittamista koskeva valtioneuvoston pää-tösehdotus. – Työryhmän mietintö. Ympäristöministeriö.
102. Suurmyymälätyöryhmän mietintö. Ympäristöministeriö.
103. Kilpi, Mikael & Asanti, Timo (toim.): Saaristolinnuston suojeleminen nykytila Suomen rannikoilla. Suo-men ympäristökeskus.
104. Björklöf, Katarina: Merkkigeenien käyttö geeniteknisesti muunnettujen mikro-organismien seuran-taan ympäristössä. Suomen ympäristökeskus.
105. Filatov & Heinonen: Results of the Finnish-Russian Joint Study of the Lakes Onega, Ladoga and Saimaa Conducted in the Summer of 1990. Suomen ympäristökeskus.
106. Hukkanen, Tiina: Puutalo-ohjelma. Ympäristöministeriö.
107. Paldanius, Jari: Vuorovaikutteisen suunnittelun kokemuksia Suomessa. Ympäristöministeriö.
108. Biodiversiteettityöryhmä: Ympäristöministeriön toimintaohjelma luonnon monimuotoisuuden säi-lyttämiseksi. Ympäristöministeriö.
109. Lahti, Pekka; Heinonen, Sirkka; Koski, Kimmo & Tolsa, Heimo: Kestävä kehitys aluerakenteessa. Kan-sainvälisiä näkemyksiä, suomalainen sovellus. Ympäristöministeriö.
110. Water and Wastewater Management in Finland and Fifteen Other European Countries. Ympäristömi-nisteriö.
111. Luontokoulutyöryhmä: Luontokoulutoiminta. Palvelut. Kehittämissideat. Verkostot. Ympäristömi-nisteriö.
112. Sipilä, Kaija: Luonto- ja leirikoulutoiminta osana maaseudun kehittämistä. Ympäristöministeriö.
113. Itämeren tila. Ympäristöministeriö.
114. Siikanen, Antti: Kotitalous ja asumismenot. Selvitys lama-ajan asumismenoista. Ympäristöministeriö.
115. Äystö, Virpi: Rehevien järvien kunnostusten arviointi. Suomen ympäristökeskus.
116. Kleemola, Sirpa & Forsius, Martin: 6th Annual Report 1997. UN ECE Convention on Long-Range Transboundary Air Pollution, International Co-operative Programme on Integrated Monitoring of Air Pollution Effects on Ecosystems. Suomen ympäristökeskus.
117. Marttunen, Mika & Kylmälä, Petri: Kalakantojen hoitomalli Inarijärven kalaistutusten vaikutusten arvioinnissa. Suomen ympäristökeskus.

118. Viirikorpi, Paavo: Eteneekö lähiöuudistus? Paikallisten lähiöprojektien käynnistämisen arviointi. Ympäristöministeriö.
119. Mäkinen, Risto: Remonttiohjelma 1992 - 1996. – Korjausrakentamisen tutkimus- ja kehitysprojektien tulokset. Ympäristöministeriö.
120. Mähönen, Outi & Joki-Heiskala, Päivi: (toim.) AMAP-Arktisen ympäristön tila ja Suomen Lappi. Suomen ympäristökeskus.
121. Lehtoranta, Jouni: Ravinteet Itäisen Suomenlahden pintasedimentissä. Suomen ympäristökeskus.
122. Åkerblom, Satu: Erityisasuminen. Katsaus Ruotsin vanhusten asumiseen 1980- ja 1990-luvuilla. Ympäristöministeriö.
123. Seppälä, Jyri: Decision analysis as a tool for life cycle impact assessment. Suomen ympäristökeskus.
124. Lindholm, Tapio; Heikkilä, Raimo & Heikkilä, Marjo (eds.): Ecosystems, fauna and flora of the Finnish-Russian Nature Reserve Friendship. Suomen ympäristökeskus.
125. Malkki, Sirkka; Heinonen-Tanski, Helvi & Jantunen, Paula: Ympärikuotisten kompostikäymälöiden toimintavarmuus ja häiriöiden kartoitus. Ympäristöministeriö.
126. Peuhkuri, Timo: Ympäristövaikutusten arviointi energia-alan ohjelmavalmistelussa. Tapaustutkimus hallituksen energiansäästöohjelman valmisteluprosessista. Suomen ympäristökeskus.
127. Kankaanpään kulttuuriympäristöohjelma. Ympäristöministeriö.
128. Kananoja, Tapio: Turun ja Porin läänin kallioperän suojelu- ja opetuskohteita. Ympäristöministeriö.
129. Kaavoitustoimen seuranta 1996. Ympäristöministeriö.
130. Asumistuesta itselliseen asumiseen vai toimeentulotukeen? I osaraportti. Ympäristöministeriö.
131. Melanen, Matti & Ekqvist, Marko (toim.): Suomen ilmanpäästöt ja niiden skenaariot (SIPS-projekti) Tietojärjestelmän tietopohja ja alustavia tuloksia. Suomen ympäristökeskus.
132. Nikulainen, Virpi & Pyy, Outi: Huoltoasemien maaperän kunnostus. Suomen ympäristökeskus.
133. Isaksson, Kaj: Korjausrakentaminen asunto-osakeyhtiöissä ja aravavuokrataloissa. Ympäristöministeriö.
134. Larjavaara, Ilmari: Asuntojen yksityistäminen Pietarissa. Ympäristöministeriö.
135. Liukkonen, Matti: Asukkaat asumisoikeusasuntojen suunnittelussa. Ympäristöministeriö.
136. Koski, Kimmo & Lahti, Pekka: Kaupan suuryksiköt ja kunnallistalous – Herkkyysanalyysi. Ympäristöministeriö.
137. Suomen biologista monimuotoisuutta koskeva kansallinen toimintaohjelma 1997 - 2005. Ympäristöministeriö.
138. Karvinen, Päivi: Kansalaisten kokemuksia YVA-menettelyyn osallistumisesta. Ympäristöministeriö.
139. Kiviniemi, Markku & Sulankivi, Kristiina: Talonrakentamisen ja kiinteistönhoidon laatujärjestelmien tilanneselvitys. Ympäristöministeriö.
140. Seppälä, Timo: Torjunta-aineiden käyttäytyminen Suomen ympäristöoloissa. Suomen ympäristökeskus.
141. Mujunen, Satu-Pia; Teppola, Pekka & Minkkinen, Pentti: Metsäteollisuuden aktiivieläytösten toiminnan monimuuttujainen seuranta ja mallintaminen. Kaakkois-Suomen ympäristökeskus.
142. Teollisuuslaitoksen ympäristömelu. Ympäristöministeriö.
143. Ilmansuojelun neuvottelukunta: Ilmansuojelututkimuksen kehittämisohjelma 2001. Ympäristöministeriö.
144. Hudd, Richard & Kälax, Pia: 0+ kalanpoikasten esiintyminen ja 0+ kalanpoikasten esiintymisbiotoopit Kyrönjoen alaosalla. Länsi-Suomen ympäristökeskus.
145. Rautio, Mika: Ympäristönsuojelun hallinnollis-oikeudellinen ohjaus kemiallisen metsäteollisuuden vesiensuojelussa. Suomen ympäristökeskus.
146. Kulttuuriympäristön hoito-ohjelma 1997-98. Etelä-Savo ja Häme. Etelä-Savon ympäristökeskus.
147. Koskiaho, Kristiina (toim.): Eheyttävän suunnittelun haasteet. Neuvottelupäivät ympäristöministeriössä 1997. Ympäristöministeriö.
148. Vehmas, Jarmo; Malaska, Pentti; Luukkanen, Jyrki & Kaivo-oja, Jari: Ympäristöpoliittiset ohjauskeinot uusiutuvien energialähteiden käytön edistämiseksi. Ympäristöministeriö.
149. OECD arvioi maamme ympäristöpolitiikkaa. Yhteenveto arvioinnin päätelmistä ja suosituksista. Ympäristöministeriö.
150. Environmental Policies in Finland. Background papers for the OECD Environmental Performance Review of Finland 1997. Ympäristöministeriö.
151. Tanskanen, Juha-Heikki: Valtakunnallisten yhdyskuntajätteen hyödyntämistavoitteiden saavutettavuus Päijät-Hämeessä. Suomen ympäristökeskus.
152. Vanhojen metsien suojelutyöryhmä: Vanhojen metsien suojelu Pohjois-Suomessa. Vanhojen metsien suojelutyöryhmän osamietintö III, osa II karttaliitteet. Ympäristöministeriö.
153. Riihimäki, Juha & Hellsten, Seppo: Konnivesi-Ruotsalaisen säännöstelyn vaikutukset rantavyöhykkeessä. Suomen ympäristökeskus.
154. Natura 2000 -ehdotuksesta annetut lausunnot. Yhteenvedot ministeriöide, asiantuntijatahojen sekä järjestöjen ja edunvalvontatahojen lausunnoista. Ympäristöministeriö.
155. Kokko, Kai: Ympäristövaikutusten selvittäminen seutu- ja yleiskaavoituksessa – oikeudellisestänäkö-kulmasta. Ympäristöministeriö.
156. Räihä, Ulla: Alavuden kulttuuriympäristön hoito. Ympäristöministeriö.
157. Rönkä, Kimmo; Halomo, Jyrki; Huhdanmäki, Aimo; Teerimo, Seppo; Terho, Juha & Tolsa, Heimo: Hissi vanhaan kerrostaloon. Taloudellinen kannattavuus, sosiaalinen tarpeellisuus sekä hallinnolliset ja taloudelliset edellytykset. Ympäristöministeriö.
158. Leskelä, Ari; Hudd, Richard; Kälax, Pia & Kjellman, Jakob: Kevätkutuisten kalalajien lisääntyminen Lappsundinjoella 1990–96. Länsi-Suomen ympäristökeskus.
159. Hyvärinen, Marketta: Ympäristövaikutusten arvioinnin kehittäminen metsätalouteen liittyvässä suunnittelussa – esimerkkisuunnittelujen tarkastelu. Pohjois-Pohjanmaan ympäristökeskus.
160. Marttunen, Mika: Vaihtoehtoisten kuormitustavoitteiden vaikutukset sisävesissä. Suomen ympäristökeskus.

161. Melanen, Matti (toim.): Jätealan tutkimuksen puiteohjelma 1998 –2002. Suomen ympäristökeskus.
162. Ympäristön seurannan strategia. Ympäristöministeriö.
163. Tamminen, Pertti; Pakarinen, Kimmo; Lintilä, Janne & Salmela, Arto: Kunnan nettotulot kerrostalo-, rivitalo- ja omakotialueilla. Tutkimuskohteena Tampere. Ympäristöministeriö.
164. Saarikoski, Heli: Ympäristövaikutusten arviointi jätehuollon strategisessa suunnittelussa. Suomen ympäristökeskus.
165. Andersson, Harri: Lounais-Suomen saaristo - valtakunnallisen alueidenkäyttötavoitteiden näkökulmasta. Ympäristöministeriö.
166. Andersson, Harri: Sydvästra Finlands skärgård - med tanke på de riksomfattande målen för markanvändning. Ympäristöministeriö.
167. Nippala, Eero; Nuutila, Harri & Rintanen, Risto: Asuinrakennusten peruseräparannustarpeen vaihtoehtoja 1996–2005. Ympäristöministeriö.
168. Wahlberg, Niklas & Aalto, Jari (toim.) Suomen uhanalaisia lajeja: tummaverkkoperhonen (*Melitaea diamina*). Suomen ympäristökeskus.
169. Kuussaari, Mikko; Pöyry, Juha; Savolainen, Markku & Paukkunen, Juho: Suomen uhanalaisia lajeja: lehtohopeatäplä (*Clossiana titania*). Suomen ympäristökeskus.
170. Lindström, Marianne (ed.): Water Legislation in Selected Countries - a Comparative Study for South African Water Law Review. Suomen ympäristökeskus.
171. Mäkinen, Risto: Rakentamisen vastuut ja laatu. Selvitysmiehen raportti. Ympäristöministeriö.
172. Nurmi, Paula: Eräiden Suomen järvien pohjaeläimistö. Valtakunnallisen seurannan tulokset 1989–1992. Suomen ympäristökeskus.
173. Haverinen, Kalervo & Lempinen, Petri: Omin avuin, valtion varoin. Opiskelija-asuntojärjestelmä Suomessa. Ympäristöministeriö.
174. Vaitomaa, Jaana: Sinilevien ja niiden tuottamien maksatoksiinien käyttäytyminen imeytyksessä. Koikeita harju- ja sedimenttipatsailla. Suomen ympäristökeskus.
175. Porvari, Petri & Verta, Matti: Elohopea ja metyylielohopea tekoaltaissa ja Kemijoen vesistössä. Suomen ympäristökeskus.
176. Hyvärinen, Veli (toim.) Hydrologinen vuosikirja 1994. Hydrological Yearbook 1994. Suomen ympäristökeskus.
177. Suomen tekemät kansainväliset ympäristösopimukset. Ympäristöministeriö.
178. Helin, Juha: Turvetuotantovelvoitteita koskevat vesituomioistuinten lupapäätökset. Suomen ympäristökeskus.
179. Soveri, Jouko; Peltonen, Kimmo & Järvinen, Olli: Laskeuma Helsingin seudulla lumesta määritettynä talvikaudella 1995 - 1996. Suomen ympäristökeskus.
180. Vesala, Riitta: Näkökulmia asemakaavaselostuksen uudistamiseen. Ympäristöministeriö.
181. Kujala-Räty, Katariina; Hiisvirta, Leena; Kaukonen, Marke; Liponkoski, Markku & Sipilä, Annika: Talusveden laatu Suomessa vuonna 1996. Suomen ympäristökeskus.
182. Rusanen, Pekka; Mikkola-Roos, Markku & Asanti, Timo: Merimetso *Phalacrocorax carbo* - Musta viikinki. Merimetson kannan kehitys ja siihen vaikuttavat tekijät Itämeren piirissä ja Euroopassa. Suomen ympäristökeskus.
183. Haukkasalo, Hannu: Kuntarakenne - yleiskaava Nurmijärvi. Ympäristöministeriö.
184. Ostamo, Eira & Hilden, Mikael: YVA-yhteysviranomaisten lausuntojen laatu - ympäristövaikutusten arviointimenettelyt 1994 - 1997. Ympäristöministeriö.
185. Lehtonen, Elina & Kangasjärvi, Jaakko: Biotekniikan riskit? Siirtogeenisten kasvien ympäristöriskit Suomen oloissa. Suomen ympäristökeskus.
186. Heikkilä, Mikko, Karppinen, Seppo & Santasalo, Tuomas: Parempi kaupunkikeskusta - seitsemän kaupunkikeskustan kehittäminen. Ympäristöministeriö.
187. Lankinen, Markku: Lähiöt muuttuvat ja erilaistuvat - 36 lähiön tilastollinen seuranta 1980 - 95. Ympäristöministeriö.
188. Räike, Antti & Pietiläinen, Olli-Pekka: Typpikuormituksen vaikutus Lohjanjärven ja sen alapuolisen vesialueen tilaan. Suomen ympäristökeskus.
189. Pietiläinen, Olli-Pekka & Niinioja, Riitta: Typpi ja fosfori Pyhäselän rehevöitymisen säätelijöinä. Suomen ympäristökeskus.
190. Jauho, Mikko & Allt, Anu: Kokemuksia laitosten muuttamisesta asuinkäyttöön. Ympäristöministeriö.
191. Mustonen, Tuija: Mäntyharjun kulttuuriympäristön hoito-ohjelma. Etelä-Savon ympäristökeskus.
192. Kylä-Setälä Annamaija: Maaperänsuojelun toteutuminen alueellisella tasolla - esimerkkinä Satakunta. Suomen ympäristökeskus.
193. Lonka Harriet: Öljy- ja kemikaalivahinkojen torjuntavalmiuden tilan selvitys ympäristövahinkojen torjunnan näkökulmasta. Suomen ympäristökeskus.
194. Niemi, M.; Kulmala, A.; Vanhala, P; Kulokoski, V. & Esala, M.: Orgaanisten jätteiden vaikutukset maaperän mikrobistoon ja kasvien typensaantiin. Suomen ympäristökeskus.
195. Lehtinen, Tana; Mattsson; Engström; Nakari; Ahtiainen & Lagus: Happikemikaalien käyttöön perustuvan massanvalkaisun ympäristövaikutuksia. Suomen ympäristökeskus.
196. Liikanen, Anu: Torjunta-aineiden käyttäytyminen ilmakehässä - lähteet, kulkeutuminen ja poistumismekanismit. Suomen ympäristökeskus.
197. Ahonen, Ilpo, Jalkanen, Aija & Vähäsöyrinki, Asko: Työntekijöiden kemikaalialistuminen saastuneiden maa-alueiden kunnostuksessa. Suomen ympäristökeskus.
198. Lukin, Markus: Kestävä tuote- ja kulutuspolitiikka - kansainväliset lähtökohdat, kansallinen sisältö ja kaupan näkökulma. Ympäristöministeriö.
199. Honkatukia, Juha: Ympäristöverot ja työllisyys. Katsaus tutkimustuloksiin ja toimenpiteisiin Pohjoismaissa ja Hollannissa. Ympäristöministeriö.
200. Tulonen, Annu: Asikkalan kulttuuriympäristöohjelma. Ympäristöministeriö.
201. Hilden, M.; Tahvonen, O & Valsta, L.: Natura 2000-verkoston vaikutusten arviointi. Suomen ympäristökeskus.

202. Vaajasaari, Kati: Liukoisuus- ja biopestit jätteiden kaatopaikkakelpoisuuden määrittämisessä. Loppuraportti. Pirkanmaan ympäristökeskus.
203. Helminen, H.; Häkkinen, K.; Keränen, M.; Koponen, J.; Laihanen, P. & Ylinen, H.: Turun edustan virtaus- ja vedenlaatumalli. Lounais-Suomen ympäristökeskus.
204. Ollila, Markku (toim.): Vesistöjen käyttöön liittyvä taloudellinen varallisuus. Suomen ympäristökeskus.
205. Otterström, Thomas, Gynther, Lea & Laurikka, Harri: Ympäristökustannusten arviointimenetelmät. Ympäristöministeriö.
206. Grönroos, Juha; Nikander, Antero; Syri, Sanna; Rekolainen, Seppo & Ekqvist, Marko: Maatalouden ammoniakkipäästöt. Suomen ympäristökeskus.
207. Liike- ja palvelurakennusten kuntoarvio. Ympäristöministeriö.
208. Hirvonen, Jukka: Toimivatko tulorajat. Tilastollista perustietoa aravatulorajojen toimivuudesta. Ympäristöministeriö.
209. Huuttula, Timo: Present state and future fate of Lake Võrtsjärv. Results from Finnish - Estonian joint project in 1993 - 1997. Pirkanmaan ympäristökeskus.
210. Tiitinen, Virpi & Vesanen, Pirjo: Ongelmia asunnottomuuden vähentämisessä. Toimenpide-ehtotuksia tilanteen parantamiseksi. Ympäristöministeriö.
211. Leppävuori, Keijo; Lehtinen, Ilkka; Aho, Timo & Lampinen, Veikko: Kiinteistöjen ylläpidon kustannusindeksi 1995 = 100. Ympäristöministeriö.
212. Siistonen, Pasi: Kaavin kulttuuriympäristöohjelma. Ympäristöministeriö.
213. Mattinen, Maire (toim.): Olavinlinna. Maisema ja monumentti. Ympäristöministeriö.
214. Saarela, Jouko; Kink, Hella; Karise, Vello; Kokkonen, Teemu; Hepojoki, Antti & Kotola, Jyrki (eds): Environmental impact of the former military base in the Pakri Peninsula, Estonia. Suomen ympäristökeskus.
215. Jätealan seurantajärjestelmä. Jäteseurantaprojektin loppuraportti. Suomen ympäristökeskus.
216. Juutinen, Artti & Mäenpää, Ilpo: Metallijätteiden kierrätyksen talous - ja ympäristövaikutukset. Ympäristöministeriö.
217. 7th Annual Report 1998. UN ECE Convention on Long-Range Transboundary Air Pollution. International Cooperative Programme on Integrated Monitoring of Air Pollution Effects on Ecosystems. Suomen ympäristökeskus.
218. Forsius, M.; Guardans, R.; Jenkins, A.; Lundin, L. & Nielsen, K.E. (eds): Integrated Monitoring: Environmental Assessment through Model and Empirical Analysis. Suomen ympäristökeskus.
219. Karjalainen, Anneli; Taipale, Lauri & Syri, Sanna: Happamoitumistoimikunnan mietintö. Ympäristöministeriö.





**ENVIRONMENTAL  
PROTECTION**

## Monitoring and Control Practices of Emissions in Pulp and Paper Industry in Finland

Emission monitoring provides data for ensuring that the operation of the plant fulfils the national requirements. It also provides data for national and international surveys and reporting. Harmonizing of both the monitoring methods and the data processing chain is necessary in order to obtain reliable and comparable data.

ISBN 952-11-0308-6

ISSN 1238-7312

Sale of publications:

Finnish Environment Institute

e-mail: [neuvonta.syke@vyh.fi](mailto:neuvonta.syke@vyh.fi)

Tel. +358 9 4030 0100 telefax +358 9 4030 0190

and Edita Ltd

Oy EDITA Ab  
PL 800, 00043 EDITA, vaihde (09) 566 01  
ASIAKASPALVELU  
puh.(09) 566 0266, telefax (09) 566 0380  
EDITA-KIRJAKAUPAT HELSINGISSÄ  
Annankatu 44, puh. (09) 566 0566  
Eteläesplanadi 4, puh. (09) 662 801



9 789521 103087