REPUBLIC OF ESTONIA
MINISTRY OF THE ENVIRONMENT

EESTI-ŠVEITSI KOOSTÖÖPROGRAMM
ESTONIAN-SWISS COOPERATION PROGRAMME

ESTONIAN ENVIRONMENTAL INFORMATION WILL BECOME MORE ACCURATE

Estonian-Swiss cooperation programme “Enhancing public environmental monitoring capacities”

CONTENTS


Photo: Kaupo Kikkas

The minister's address

In the olden time there was a saying, "Skilled men and Swedish tools, what more could one want for excellent work!" The saying is still very much to the point today. The modern version could be "Wherever the Swiss Franc and skilled men are involved, environmental monitoring is pure joy".

MARKO POMERANTS
Minister of the Environment

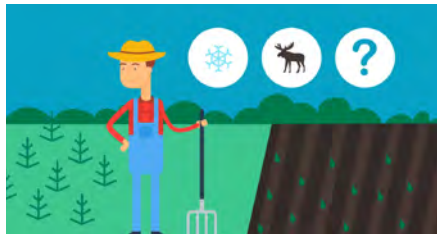
To prevent Liisa Pakosta, the Estonian Gender Equality and Equal Treatment Commissioner from telling me off, I must stress that both sayings are gender-neutral by nature. And the tools are still great in modern times. Everyone, who has seen as many a winter as I have, remember the wooden triangulation points in Estonian landscapes. These tended to rot and collapse. However, now we have the posh GNSS stations across Estonia and one can find out their location with a precision of a centimetre. We also have enough natural scientists for almost every institution of higher education. It might be that they are as diligent enthusiasts as is Peep Lassmann, the rector of the Estonian Academy of Music and Theatre, who is namely a bird watcher.

We procured nothing for the musicians, but institutes of our different higher education institutions received many valuable tools with the help of the programme, which enable collecting significant environmental data. Nothing important should go amiss anymore in both air and water.

As a minister, I am pleased with the events and thank the donors. All that is left to do now is to explain the meaning of these collected high-quality monitoring data to people in an intelligible way. But this is already a quote from the next book, from the foreword to the yearbook on environmental monitoring.

Switzerland contributed 8.5 million francs into Estonian environmental monitoring

Swiss Confederation allocated 8.5 million Swiss francs (approx. 7 million euros) for supporting Estonian environment within the Estonian-Swiss cooperation programme.



Under the leadership of the Ministry of the Environment, the programme "Enhancing public environmental monitoring capacities" was launched for allocating these resources. The programme was conducted from 2012 to 2016 and 11 projects received financial assistance within the programme. The assistance recipients included responsible executors and performers of the national environmental monitoring programme.

The objectives of the programme are as follows:

- Growth of the reliability of the Estonian environmental monitoring system (i.e., higher sensitivity of definite indicators, increased precision of determination);
- Increase in the scope of the Estonian environmental monitoring system (i.e., larger geographic coverage and number of monitoring indicators about which data are collected);
- Improved efficiency of the Estonian environmental monitoring system (i.e., the speed of transmitting monitoring data from monitoring stations to the central databases will increase; the cost and operating time required for producing monitoring information will decrease)

Read more at http://www.envir.ee/et/eesti-sveitsi-koostooprogramm

Watch the video clip "Environmental monitoring and you. Estonian-Swiss cooperation programme" at

https://www.youtube.com/watch?v=OSvxz5cY5Rs

The following projects are implemented within the programme:

WATER

Increasing the capability of environmental monitoring on Estonian lakes and rivers
Grant recipient: Estonian University of Life Sciences

Airborne remote sensing of Estonian environment
Grant recipient: University of Tartu

Modernising of measurement hardware for Estonian coastal monitoring programme
Grant recipient: OÜ Eesti Geoloogiakeskus

Increasing efficiency of Estonia to analyse priority hazardous substances
Grant recipient: Eesti Kekskonnauuringute Keskus OÜ

Increasing efficiency of environmental monitoring in Southern Estonia
Grant recipient: Eesti Keskkonnauuringute Keskus OÜ

Development of sustainable groundwater monitoring system of Estonia
Grant recipient: Ministry of the Environment

Enhancing offshore monitoring capacities through the implementation of new technologies of the contact measurement
Grant recipient: Tallinn University of Technology

Establishment of the GPS-RTK Permanent Station Network*
Grant recipient: Land Board

Distribution by subject fields

AIR

Updating of the equipment of the Tahkuse Air Monitoring Station
Grant recipient: University of Tartu

Strengthening of Estonian air quality network: Source apportionment of the fine particulate matter
Grant recipient: Eesti Keskkonnauuringute Keskus OÜ

Establishment of the GPS-RTK Permanent Station Network*
Grant recipient: Land Board

RADIATION

Upgrading of the radiation monitoring in Estonia
Grant recipient: The Environmental Board

Establishment of the GPS-RTK Permanent Station Network*
Grant recipient: Land Board

* This is a project that supports all sectors.

Project **1**

Establishment of the GPS-RTK Permanent Station Network

GRANT RECIPIENT:
LAND BOARD

PROJECT DEADLINE:
May 2016

Total cost of the project	CHF 1,178,191	(1,033,887.45 euros)
Incl. Swiss support	CHF 1,001,462.35	(878,804.33 euros)
Incl. co-financing from the state budget (15%)	CHF 176,728.65	(155,083.12 euros)

Under the leadership of the Land Board, **a new pan-Estonian network of permanent stations for the global navigation system** was established in 2014–2015, implementing the most modern GNSS-RTK (global navigation satellite system in real time kinetic) measurement technology. The GNSS-RTK network ensures the availability of an accurate position-based information in the whole state.

GNSS permanent stations (2007–2008)
GNSS equipment was replaced on this project

New GNSS permanent stations (2014–2015)

The modern network of permanent stations ensures accurate position-based information

Under the leadership of the Land Board, a new pan-Estonian network of permanent stations for the global navigation system was established in 2014–2015, implementing the most modern GNSS-RTK (global navigation satellite system in real time kinetic) measurement technology. The GNSS-RTK network ensures the availability of an accurate position-based information in the whole state.

The first permanent GNSS station was established in Estonia in the Suurupi lighthouse in 1996. An additional 8 permanent GNSS stations were installed in 2007–2008. Since the network devices of these stations were out of date, the network of permanent stations too sparse and of insufficient quality to ensure accurate positioning, the existing network of permanent stations was decided to be modernized.

Photos: Karin Kollo

New permanent stations in Mustjala and Vergi

18 new permanent stations

Within the Estonian-Swiss cooperation programme, 18 new permanent GNSS stations were installed in Estonia in 2014–2015 to ensure a real-time GNSS service. Therefore, the Land Board's GNSS-RTK network of permanent station currently includes 27 permanent stations. Within the Swiss project, the first station was installed in Märjamaa in August 2014 following a few years of preliminary works, starting from looking for suitable locations for installing the station, conducting the public procurement, and making an agreement with the owners of the building for installing a permanent station.

The permanent GNSS station consists of an external GNSS antenna and antenna mast, and a GNSS receiver installed inside the building. Within the project, meteo sensors that allow registering different weather phenomena, thus providing valuable information about the troposphere's condition, were installed for 13 permanent stations. In addition, 11 mobile stations and a control station for the GNSS-RTK network that is essentially its "brain" were acquired.

In the network established earlier, there were altogether 9 permanent GNSS stations that were located in a distance of approx. 150–200 km from each other, which did not suffice for performing accurate real-time measurements. In the new network, distances between networks total approx. 50 km. In addition, the equipment of 9 earlier permanent stations was replaced, because the devices used were no longer reliable. Earlier, two kinds of receivers were in use in the network for permanent GNSS stations, incl. devices from the GPS-500 and GPS1200 series. However, the new network is based on a common technology, using GNSS GR25 receivers and GNSS AR25 antennas.

Accuracy of positioning is up to 1 cm

The network for permanent stations allows its operators to position in real time with an accuracy of 1–5 cm. Satellite measurements are used for an accurate determination of coordinates. Permanent stations record data sent from satellites 24/7 and use these to calculate the coordinates of its position. This information can be used in different fields. Structural units of the Land Board use the permanent station network for checking the borders of cadastral units, taking aero-photos and laser scanning, external mapping, test measurement of the coastline, test measurement of geodesics, etc. The information is also used for different environmental monitoring and agricultural purposes by the Estonian Agricultural Registers and Information Board (ARIB), Information Technology Centre of the Ministry of the Environment (KEMIT), State Forest Management Centre (RMK) and Estonian Crop Research Institute (ETKI), etc.

Several opportunities for environmental monitoring

Position-based information can be used, in the future, also for other environmental monitoring, such as for monitoring the status of bodies of water, groundwater tests, air quality monitoring, radiation level and coastal area monitoring, etc. In addition, the network service may be used as a basis for the emergency situation monitoring system.

Since 2008, four permanent stations in Estonia are switched in the composition of the pan-European network for permanent GNSS stations (EPN). The established network may be connected with similar networks of other European states. For example, Land Board is cooperating with the Latvian Geospatial Information Agency (LGIA), due to which the service can be used in the border area between Estonia and Latvia. In the near future, cooperation is planned to be launched with the Finnish Geospatial Research Institute. Cooperation with the Estonian Maritime Administration ensures the proximity and use of real-time corrections of the data from permanent GNSS stations in the Estonian coastal zone. Since spring 2015, a “densification” project of EPN was launched, where Estonian permanent GNSS stations are planned to be switched in the future as well.

Project **2**

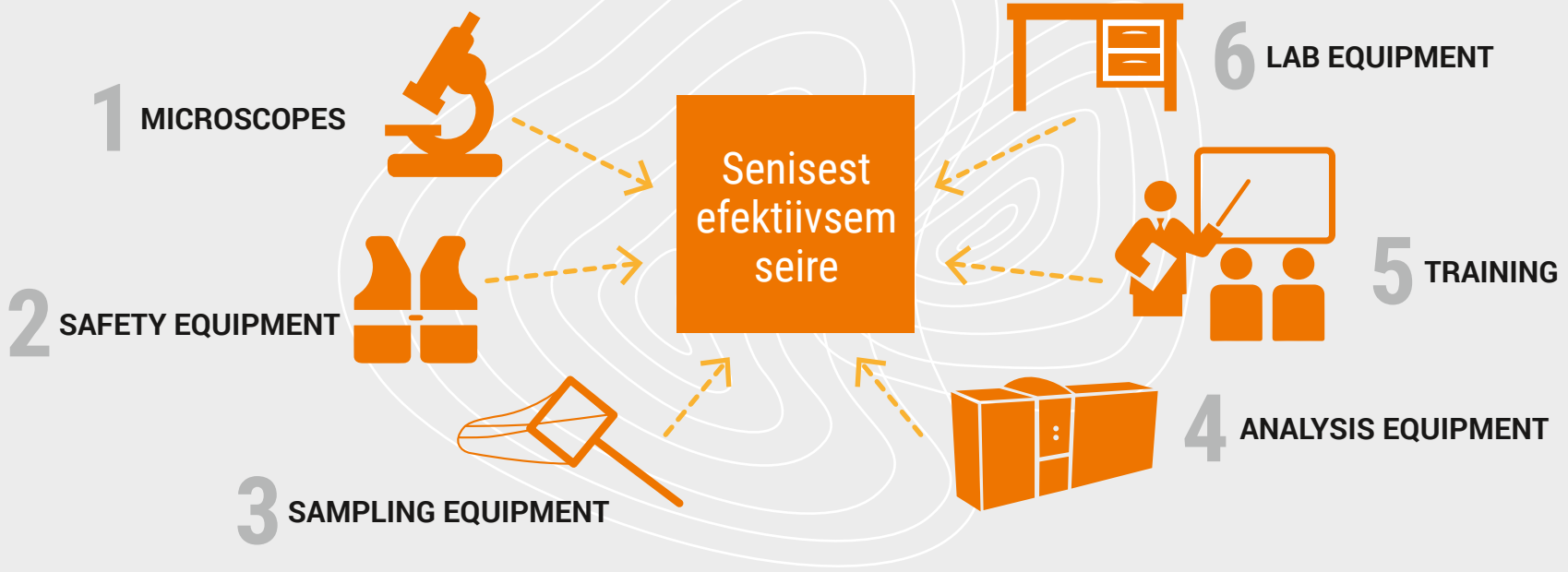
Increasing the capability of environmental monitoring on Estonian lakes and rivers

GRANT RECIPIENT:
ESTONIAN UNIVERSITY OF LIFE SCIENCES

PROJECT DEADLINE:
February 2016

Total cost of the project	CHF 1,170,390	(959,166.88 euros)
Incl. Swiss support	CHF 994,831.50	(815,291.85 euros)
Incl. co-financing from KIK and Estonian University of Life Sciences (15%)	CHF 175,558.50	(143,875.03 euros)

The Estonian University of Life Sciences acquired modern sampling equipment, analysis equipment, tools for studying water-biota and continuous measurements, the lab equipment for the Centre for Limnology, and safety equipment.



The environmental monitoring capability of Estonian inland water was improved

Estonian University of Life Sciences modernized equipment used for the national environmental monitoring of Estonian lakes and rivers, which significantly improved the reliability and capability of the monitoring system of Estonian inland water.

The volume of biological monitoring of Estonian inland water has significantly increased over the last few years, but the existing infrastructure did not enable collecting all the necessary information for assessing the condition of bodies of water. In addition, the environmental monitoring did not entirely meet the European Union standards. Many tools used for monitoring were depreciated and inaccurate and the analyses conducted therewith were labour and time consuming. For certain analyses, such as the assessment of internal loading of nutrient salts in bodies of water, study of bathymetry and bottom topography, conducting continuous measurements, etc.
The safety of monitoring operations was also not sufficiently guaranteed.

More efficient monitoring

With the help of the Estonian-Swiss cooperation programme, the Institute of Agricultural and Environmental Sciences of Estonian University of Life Sciences acquired modern sampling and analysis equipment, high-quality microscopes for studying water-biota and tools for continuous measurements. A large part of the cooperation programme finances were invested in updating the lab equipment of the lately renovated Centre for Limnology. The acquired safety equipment included a new life raft, a waterproof survival suit and immersion suits, as well as life jackets, which are all required to ensure safety in field work conducted on lakes and rivers. With the support of the programme, the "Identification guide to freshwater macroinvertebrates of Estonia" (by Henn Timm) was published in English and Estonian with a long-term positive effect on the monitoring capability of lakes and rivers.

Suppliers of equipment also conducted user training courses to show, how to use the new tools correctly and accurately. For example, the two-day training for RiverSurveyor, which is used for measuring flow rate, depth and flow volumes, was held near Lake Võrtsjärv and conducted by Lee Pimble from England.

The modernization of tools and equipment significantly increased the efficiency of environmental monitoring of inland water, as well as the quality and availability of data. From now on, data are better comparable on the international level. As a result of the project, the Estonian University of Life Sciences is able to provide state authorities and the public of the necessary environmental information in a timely manner. The higher-quality database is a good input for developing water economy plans made for improving the condition of Estonian nland water. Among other things, complex and detailed research is needed to specify the reasons for the worsening condition of lakes, which was thus far hindered by insufficient technology. For example, the research of the lake's internal nutrient cycle and sediments was complicated due to a lack of suitable equipment.

User training for the RiverSurveyor system by the Emajõgi River. Lee Pimble, the training provider from England is on the left

Project **3**

Upgrading of the radiation monitoring in Estonia

GRANT RECIPIENT:
ENVIRONMENTAL BOARD

PROJECT DEADLINE:
April 2016

Total cost of the project	CHF 598,839	(503,584.39 euros)
Incl. Swiss support	CHF 509,013.15	(428,046.73 euros)
Incl. co-financing from the state budget (15%)	CHF 89,825.85	(75,537.66 euros)

Introduction of the new monitoring network guarantees that the residents receive **timely and relevant** information about the radiation situation in the state.

In case of a radiation level that exceeds the alarm level, the stations transmit an automatic notice to the rescue team of the Radiation Safety Department, which will analyse the receive information within 10–15 minutes and notify the relevant authorities and the public, if necessary.

Radiation monitoring station, manufactured by Envinet GmbH

https://remap.jrc.ec.europa.eu/GammaDoseRates.aspx

Estonian radiation monitoring achieved a new level

The Radiation Safety Department of Environmental Board acquired a new, modern and reliable automatic monitoring network, which enables receiving accurate and prompt information regarding air radiation levels across Estonia.

Pursuant to international agreements, Estonia is obligated to constantly survey the radiation level and manage the early warning system of radiological risk. The early warning system enables to quickly discover the cross-border spread of a radioactive substance in the Estonian territory, as well as to measure the radiation level and content of radioactive substances in the air. In case of serious nuclear and radiological accidents, when radioactive pollution may cross state borders in the atmosphere, for example, it is important to become aware of the seriousness of such a risk and peculiarities of the spread of pollution as soon as possible. In this case, emergency decisions may be taken to protect the population, if necessary.

The monitoring network acquired within the Estonian-Swiss programme consists of 15 automatic radiation monitoring stations of German origin (Envinet GmbH), which were placed across Estonia. By introducing the new monitoring network, Estonia is now better covered by monitoring stations, because the new stations replaced the 10 automatic monitoring stations that operated since 1997.

Introduction of the new monitoring station significantly increased its reliability. In addition, data transmission related to radiation monitoring was modernized and now ensures the residents with timely and relevant information about the radiation situation in the state. The monitoring stations use Geiger-Müller measurement detectors, which measure the total gamma radiation dose rate (nSv/h) and NaI crystal based detectors that measure spectral gamma radiation. These tools enable detecting radionuclides and distinguish different dose rates caused by different radionuclides. Out of these, the most important is the component caused by artificial radionuclides that stations compare with a pre-determined alarm level. In case of a radiation level that exceeds the alarm level, the stations automatically transmit a notice to the rescue team of the Radiation Safety Department that analyse the received information within 10–15 minutes and notify the relevant authorities and the public, if necessary. In addition, the air monitoring data are transmitted every hour to the EURDEP database located in Ispra, Italy (http://eurdepweb.jrc.ec.europa.eu/EurdepMap/Default.aspx), where these are available to all other authorities and the public as well.

The old and new monitoring stations in Tallinn

The air filter device discovers even finer contamination

Three air filter devices located in Harku, Narva-Jõesuu and Tõravere are used for air sampling to monitor the radioactivity or air particles and aerosols. The devices are in use throughout the year and the Radiation Safety Department lab analyses the displayed filters once a week to identify radionuclides found in the air. Compared to results registered by the automatic stations, the air filter devices enable identifying concentrations that are smaller by 2–3 magnitudes.

Within the Estonian-Swiss cooperation programme, the depreciated air filter device in Harku was replaced. The new acquired device SnowWhite JL-900 (Senya Oy, Finland) surpasses the device used before by both capacity, accuracy and reliability. Similar air filter devices are widely used across the world and in Narva-Jõesuu as well.

The air filter device located in Narva-Jõesuu was renewed within the programme to guarantee long-term smooth operation. For that, device parts essential for the device's operation (measuring system, frequency converter, heating system) were replaced and the device underwent maintenance works. The device located in Narva-Jõesuu is the closest Estonian radiation monitoring station to the Leningrad Nuclear Power Plant, which is why it plays an essential role in radiation monitoring. So that a gamma-spectrometric analysis of filters displayed in air filter devices could be conducted in the laboratory, the filters need to be compressed beforehand. The filters are exposed to 6-tonne weight that is achieved by a special hydraulic compression device. Within the project, a depreciated compression device that was in use since 1996 was replaced.

In addition, a laboratory gamma-spectrometer (Canberra, the United States of America) that is used for analysing the radionuclide content in environmental samples collected within the national radiation monitoring programme, was acquired. On an annual basis, approx. 285 environmental samples are collected and analysed within radiation monitoring. Acquisition of the new gamma-spectrometer ensures sustainable and smooth analysis of radiation monitoring samples, measure a larger number of samples in the laboratory, and improve the efficiency of identifying smaller active concentrations. The process of preparing radiation monitoring samples for analysis involves work under fume hoods, which is why it is essential to protect the lab personnel from hazardous gases and fumes during the work. The Estonian-Swiss Swiss programme helped to replace two depreciated fume hoods in the laboratory equipped with a ventilated locker for chemicals. Earlier, the special lockers intended for storing chemicals were absent.

Photo: Uko Rand

New air filter device in Harku

Project **4**

Updating of the equipment of the Tahkuse Air Monitoring Station

GRANT RECIPIENT:
UNIVERSITY OF TARTU, INSTITUTE OF PHYSICS

PROJECT DEADLINE:
March 2016

Total cost of the project	CHF 181,463	(151,211.54 euros)
Incl. Swiss support	CHF 154,243.55	(128,529.81 euros)
Incl. co-financing from KIK and the University of Tartu (15%)	CHF 27,219.45	(22,681.73 euros)

The information received with the help of new equipment enables forecasting air pollution transformation and climate change.

Automatic nitrogen dioxide **NO_2 detector** working under Saltzman method.

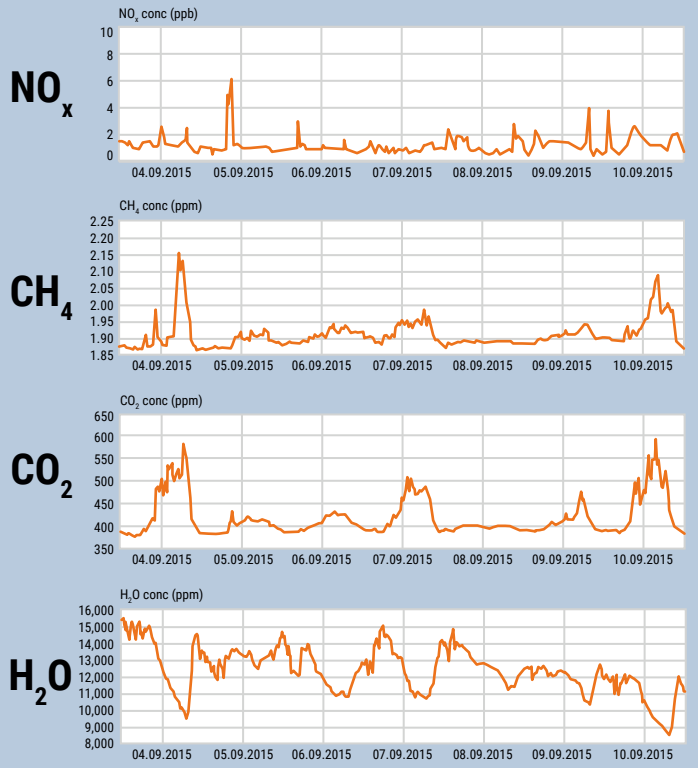
NO_2

before

Analysers of **pollutant gas** and **greenhouse gas** concentration.

SO_2 NO_x CO_2
O_3 CH_4 THC
H_2S H_2O

now



The new devices enhanced air monitoring in Tahkuse

New modern atmospheric pollution and impurity gas analysers that improve the capability and quality of identifying the chemical composition of air were introduced in the air monitoring station located in Tahkuse, Pärnu County. As a result, the Institute of Physics of the University of Tartu is now able to characterize air quality in South-West Estonia near the Soomaa National Park at a significantly perfected level.

The environmental physics lab of the Institute of Physics of the University of Tartu launched continuous air monitoring at the Tahkuse field base already in 1988. The self-made spectrometer was used for both environmental monitoring and research. The number and measuring volume of different analysed parameters has steadily increased over the years. Today, the Tahkuse station already performs long-term systematic and complex physical and chemical measurements of the atmosphere, and collects statistically significant information about the pollution parameters of the atmosphere and trends thereof. The data collected near the Soomaa National Park are also a good comparative material for other, more polluted regions. Measurement data enable studying the generation of aerosol particles and atmospheric evolution, connections with pollutant gases and meteorological conditions, as well as the dependence of air pollution and its spread on meteorological parameters. Despite of the overall good technical level of the apparatus in Tahkuse, there was only the automatic nitrogen dioxide NO_2 detector working under the Saltzman method for determining the air pollutant gases. In order to explain regional air pollution level, many more background concentration of air pollutant gases had to be measured.

The Tahkuse air monitoring station

More capable device complex

To measure more background concentrations of air pollutant gases, the University of Tartu acquired, with the support of the Estonian-Swiss cooperation programme, a new device complex that allows identifying the concentrations of seven different pollutant gas instead of one pollutant gas. The new pollutant gas analysers (altogether 6 measuring devices, including 5 from the manufacturer Thermo Fisher Scientific, Inc. and an analyser of concentrations of greenhouse gases $CH_4/CO_2/H_2O$ from the manufacturer Los Gatos Research Inc.) enable continuous measuring of concentrations of SO_2, NOx, CO_2, O_3, CH_4, THC and H_2S (as well as H_2O) in the air. This allows getting al-

most the full picture of the chemical composition of air in terms of important pollutant gases. Thanks to the new devices, monitoring of pollutant gases has significantly improved, due to which, the results of complex atmospheric-physical measurements can be analysed and changes in the regional background caused by cross-border transport of air additives can be assessed in a more complete manner. Measurements of the primary greenhouse gases H_2O, CO_2, CH_4 and O_3 also support weather and climate studies.

Good prerequisites for research

In the future, information received with the new devices can be used in studies related to air pollution transformation and climate change forecasting. Such studies would allow notifying the Estonian society of the important factors of the quality of atmospheric air, and supporting teaching environmental physics and shaping environmentally friendly mind frame at the University of Tartu. In terms of research, the supplemented Tahkuse database allows for assessing the effect of air pollution on biodiversity as well. In the near future, monitoring data collected in Tahkuse are planned to be sent to the databases of the Estonian Environmental Research Centre (EKUK), where these will be available for both professional and public use.

To ensure high quality of monitoring data, regular checks and adjustments of new devices is essential. Since it is measurement of minute concentrations or so-called background monitoring of atmospheric additive and pollutant gases, ensuring precision of measurement is especially vital. For that, the University of Tartu plans to acquire a clean air generator, which will become part of the calibration system of gas analysers in Tahkuse. As a result of performance of this additional activity, the quality of data collected in Tahkuse will increase, which will improve the national environmental monitoring in terms of background monitoring of air.

Gas analysers at Tahkuse air monitoring station

Gas analysers are being tested in environmental physics labaratory in Tartu University

Project **5**

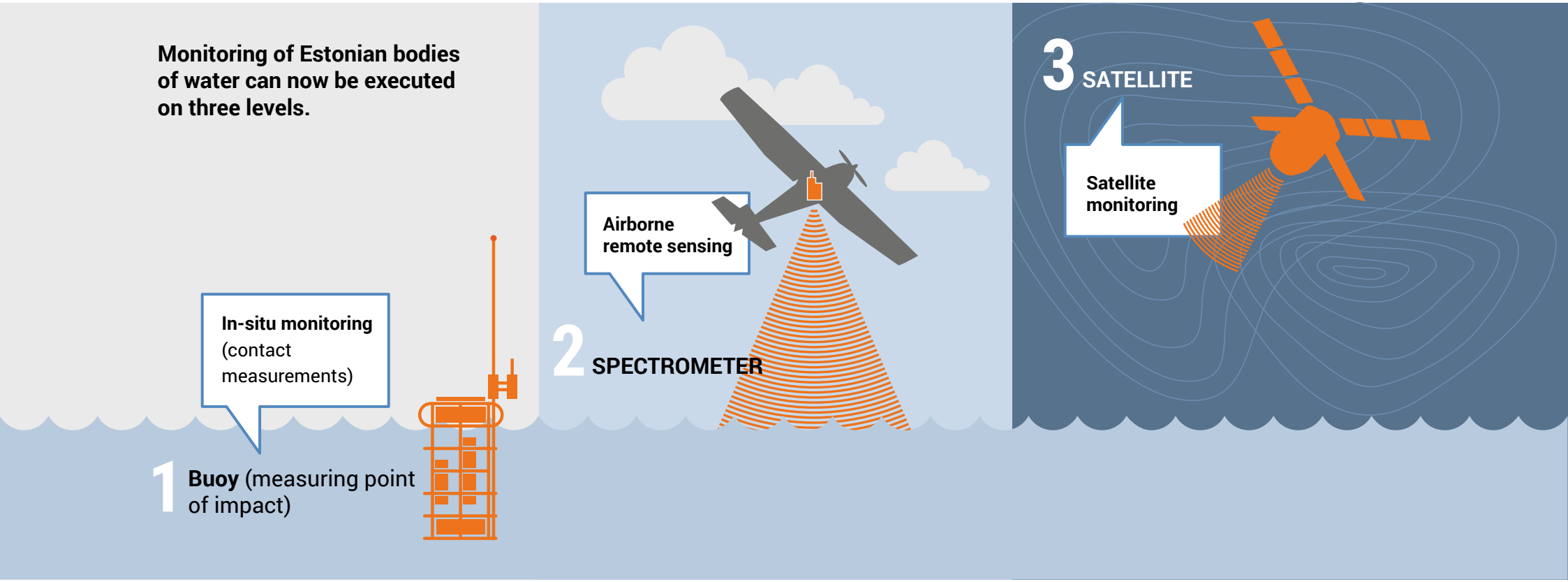
Airborne remote sensing of Estonian environment

GRANT RECIPIENT:
ESTONIAN MARINE INSTITUTE OF THE UNIVERSITY OF TARTU

PROJECT DEADLINE:
March 2016

Total cost of the project	CHF 736,879	(630,588.87 euros)
Incl. Swiss support	CHF 626,347.15	(536,000.54 euros)
Incl. co-financing from KIK and UT (15%)	CHF 110,531.85	(94,588.33 euros)

Monitoring of Estonian bodies of water can now be executed on three levels.



Estonian scientists received new tools for studying the condition of the aquatic ecosystem

The Estonian Marine Institute of the University of Tartu acquired a airborne remote sensing spectrometer for studying the condition of water and other environments, significantly improving the capability of performing Estonian environmental monitoring.

Up to now, Estonian scientists have studied water quality from ships and by satellite images. By taking water samples, information is received only about the water quality located in the point of taking the sample, but Estonian coastal sea is very variable in both time and space. Oftentimes, water quality in a small distance from point of sampling may be very different and different array stacks of water may change in the same point within hours. In addition, employing a research vessel and analysis of water samples may be very costly. By satellite images, surface water layers may be studied in large areas at the same time. Spatial resolution of satellite images used in everyday monitoring is between 300 and 1,000 m, which is not sufficient in case of a complex coastline or a special case. Satellite images are available at certain times only and unavailable in case of cloudy weather. These problems do not occur with airborne sampling.

The acquired spectrometer HySpex (Norsk elektro Optics) allows Estonia to perform airborne environmental monitoring for the first time. From now on, monitoring of sea and lakes is possible on three levels. Firstly, satellite images enable daily monitoring of some changes in environmental parameters in larger lakes and the whole Baltic Sea. Secondly, water samples enable very accurate research of many parameters, although only at certain times a year and in a few locations. Thirdly, the new spectrometer allows for studying relatively large areas in more detail than with a satellite.

Spectrometers work by the principle that it measures light that enters and exits water. Spectral changes enable assessing the transparency, depth, phytoplankton, solid particles and volume of dissolved carbon, scope of bottom

Spectrometer (small black box in the foreground) on the Land Board's plane at a time of test measurements

Optical buoy

and shore vegetation and types of their biocoenosis; map the range of effect of human activity (e.g. dredging works), extent of pollution, and identify the types and sources of pollution.

A photo made by spectrometer of shallow water area between Hiiumaa and Kaevatsi

Depth of water in most of the shallow coastal regions in Estonia were mapped before 1953. Estonian Maritime Administration owns modern ships and sonars, but these have mainly been used for mapping shipping lanes. There is not enough capacity for mapping shallow waters and it is also very dangerous to sail in shallow waters with high number of boulders. With the help of a airborne spectrometer, it is now possible to map water depth in shallow regions, where ships and sonars have no actual access.

Field of application of the device is not restricted by the water environment and it may applied on mainland as well, for example for evaluating yield on fields, mapping disease-infected field or forest land, or determine even what tree species grow in different regions. In addition to planes, spectrometers can also be used under lab conditions to interpret remote sensing data and conduct various biological research.

During test flights, capacity of the spectrometer was tested to monitor water quality on Lake Peipus and for shallow water monitoring in the West-Estonian archipelago. To test water quality parameters, test flights were conducted on Lake Peipus. Since in the summer of 2013–2014, HySpex was located on Land Board's plane, their employees activated HySpex during other tasks when flying over bodies of water as well. These data can be used in future studies of the temporal variation of bottom and shore vegetation.

Knowing that the capability of environmental condition monitoring has improved decreases the readiness of potential polluters to conduct their activities consciously. Therefore, purchase of this remote sensing spectrometer facilitates the improvement of water quality in Estonian coastal and internal bodies of water.

Optical buoy system allows for real-time monitoring

To increase dataset required for developing algorithms and to research rapid physical biological processes in the sea, the Marine Institute additionally acquired a bio-optical buoy. Owing to the optical buoy system, it is now possible to study rapid processes taking place in the Baltic Sea, the observation of which was not possible before, including overnight production variety, movement of blue-green algae in heads of water, variety of under-water light area, etc. Installation of the buoy system also enabled initiating winter measurements in Estonian coastal sea that was absent beforehand. To compare buoy data with lab analyses and conduct other measurements included in the national monitoring programme, a spectrometer was acquired to complement the buoy.

Project 6

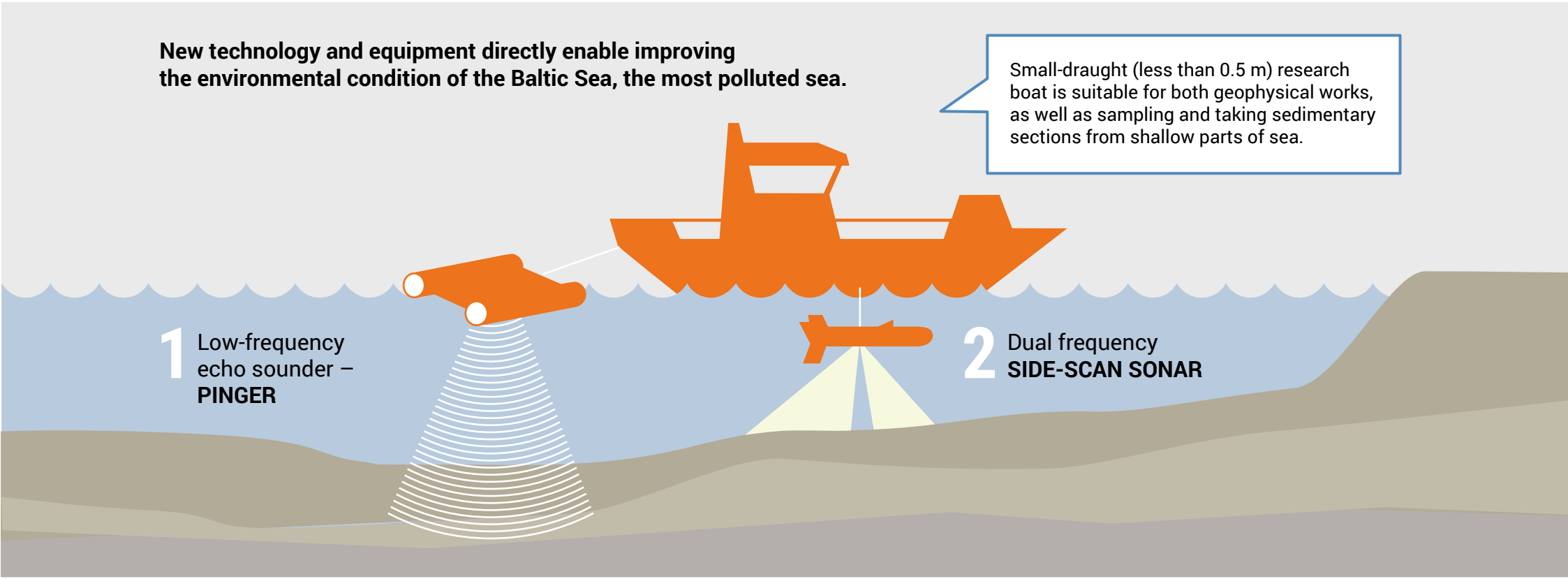
Modernising of measurement hardware for Estonian coastal monitoring programme

GRANT RECIPIENT:
OÜ EESTI GEOLOOGIAKESKUS

PROJECT DEADLINE:
June 2016

Total cost of the project	CHF 194,410	(160,684.08 euros)
Incl. Swiss support	CHF 165,248.50	(136,581.47 euros)
Incl. co-financing from KIK (15%)	CHF 29,161.50	(24,102.61 euros)

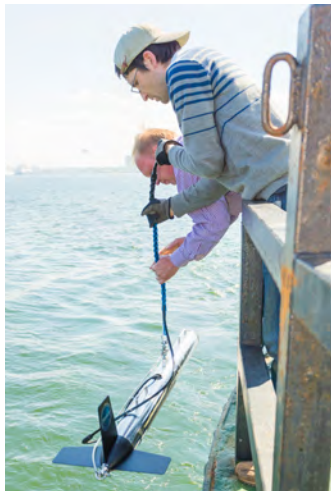
New technology and equipment directly enable improving the environmental condition of the Baltic Sea, the most polluted sea.



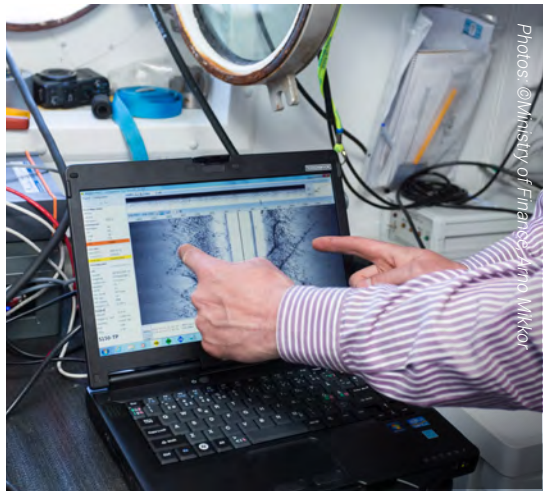
New technology increased the capability of sea-bed mapping

Geological Survey of Estonia received a modern selection of devices with the support of the Estonian-Swiss cooperation programme, resulting in better opportunities to study seacoast and mapping seabed in Estonia.

Over the last decades, use and building-up of Estonian coastline has rapidly increased, which may have a negative effect on the coast and beach environment. Negative impact is also increased by several manifestations of climate change, such as rise in water level, storms and snow-free winters. Therefore, Geological Survey of Estonia required a more modern measuring apparatus to create better conditions for studying seacoast. Geological Survey of Estonia (EGK) initiated monitoring seacoasts in 1994 and is currently responsible for conducting monitoring of seacoasts under the sub-programme of Estonian national environmental monitoring.



Launching of a side-scan sonar



Data observation

Photos: ©Ministry of Finance / Ivo Mikkor

New measuring technology

With the support of the Estonian-Swiss cooperation programme, EGK acquired a echo sounder that is used for measuring seabed relief in profiles; side-scan sonar that is used for studying seabed by surface areas; a data collection and interpretation software (Meridata MDCS and MDPS), and a set of underwater video camera.

For even more complex monitoring of coastal zone and the adjacent shallow coastal sea a research boat will be acquired. Since sediments of the beach and beach slope sediments form a single system, it is very important to observe changes occurring in the coastal zone as a whole. It is especially important to understand the processes emerging on Estonian sand beaches or holiday beaches, but also provides information concerning development trends of other beaches. These modern geophysical measuring tools allow studying the beach slope and seabed in detail both above and below a -10 m depth curve. Results of measuring data and their interpretation significantly improve the level of research completed in the coastal zone.

In the name of the cleaner Baltic Sea

The collected data are especially necessary for coastal zone planners, seaside local governments and state authorities that can make decisions about better development of the coastal zone based on the received data. Thus, it is possible to prevent and decrease environmental hazards and risks. In conclusion, the new technology directly helps to improve the environmental condition of the Baltic Sea that is the most polluted sea.

Project 7

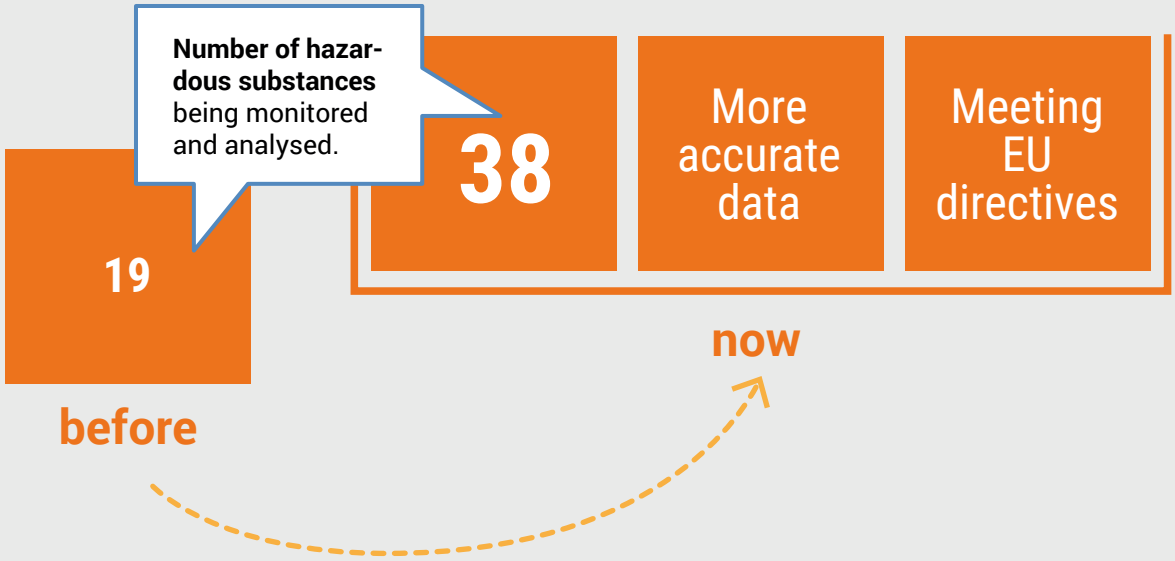
Increasing efficiency of Estonia to analyse priority hazardous substances

GRANT RECIPIENT:
EESTI KESKKONNAUURINGUTE KESKUS OÜ

PROJECT DEADLINE:
September 2015

Total cost of the project	CHF 1,783,984	(1,453,050.95 euros)
Incl. Swiss support	CHF 1,516,386.40	(1,235,093.31 euros)
Incl. co-financing from KIK and EKUK (15%)	CHF 267,597.60	(217,957.64 euros)

Reliability and quality of monitoring data, as well as meeting identification requirements established by different EU directives improved.



The Estonian Environmental Research Centre now uses new equipment:

1. gas chromatography tandem-mass spectrometer
2. liquid chromatography tandem-mass spectrometer
3. gas chromatography mass spectrometer
4. solid phase extraction apparatuses for preliminary sample treatment
5. nitrogen analyser
6. modern extraction systems
7. devices for identifying mercury

Estonian capability of identifying environmentally hazardous substances increased

Estonian Environmental Research Centre (EKUK) acquired new lab equipment for increasing the identification capability of hazardous substances, which improve the analysis of high-priority hazardous substances from any environment, such as water, soil, air and other.

An environmentally hazardous substance is an element or compound that may pose, due to its toxicity, resistance or bioaccumulation, hazard on human health and harm other living organisms or ecosystems as well. Depending on the substance, releasing it in the environment must be either limited or terminated entirely, in order to ensure a safe environmental status. Therefore, Estonia has the responsibility to monitor and analyse the content of hazardous substances in the environment. Monitoring of hazardous substances in Estonia is supported by EKUK. Up to now, Estonia lacked a sufficiently sensitive apparatus for conducting identification of hazardous substances on the required level.

Faster and more accurate results

With the support of the Estonian-Swiss cooperation programme, EKUK acquired the relevant lab equipment for identifying hazardous substances. Now, the centre implements a gas chromatography tandem-mass spectrometer, a liquid chromatography tandem-mass spectrometer, a gas chromatography mass spectrometer, a solid phase extraction apparatuses for preliminary sample treatment, a nitrogen analyser, modern extraction systems, and devices for identifying mercury.

This means that from now on, it is possible to measure, whether and what kind of hazardous substances can be found in our nature with significantly higher accuracy and precision of identification in case of very little content.

EKUK chemists implementing analysis on a gas chromatography tandem-mass spectrometer

Identification time became shorter again. Hazardous substances may be harmful for humans already in small quantity, which is why it is possible to react to changes in the situation fast.

The number of high-priority hazardous substances monitored and analysed by EKUK rose from 19 to 38. In terms of many hazardous substances, it is possible to achieve lower identification levels than determined by the Environmental Quality Standard (EQS). The modernized work environment decreases the risk of cross-contamination. In conclusion, reliability and quality of monitoring data and meeting the identification requirements established in different EU directives was improved.

Higher-quality information for research

The new lab equipment also improves the development of regional environmental monitoring and lab capability. With the help of improved environmental information quality and reliability, it is possible to make better decisions required for developing environmental protection activities and programmes. Thus, meeting Estonian national environmental obligations is improved as well. In addition, the project result helps to expand the sphere of research activity.

The new laboratory also increases Estonia's monitoring capability of substances hazardous to the environment, and expands the sphere of research activity, because analyses can be conducted of any environment.

A liquid chromatography tandem-mass spectrometer

Project 8

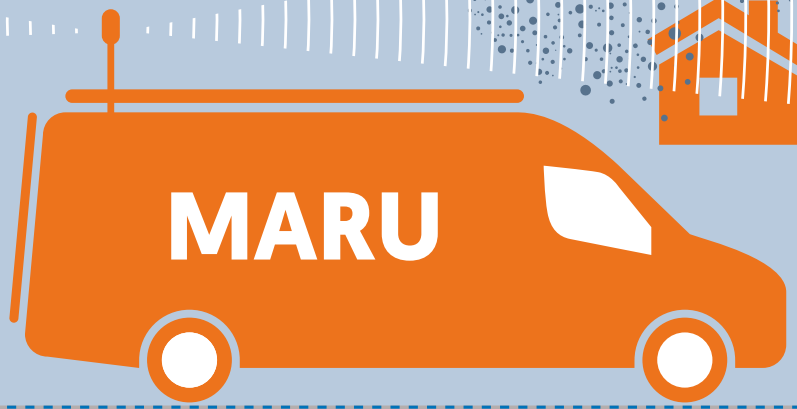
Strengthening of Estonian air quality network: Source apportionment of the fine particulate matter

GRANT RECIPIENT:
EESTI KESKKONNAUURINGUTE KESKUS OÜ

PROJECT DEADLINE:
June 2015

Total cost of the project	CHF 2,068,116	(1,687,612.29 euros)
Incl. Swiss support	CHF 1,757,898.60	(1,434,470.45 euros)
Incl. co-financing from KIK and EKUK (15%)	CHF 310,217.40	(253,141.84 euros)

Estonian Environmental Research Centre (EKUK) received a more up-to-date technology for executing air monitoring



A portable lab MARU makes it possible to measure:

1. chemical composition of ultrafine particles (with circumference of less than 1 micrometre) in the air
2. fractional division of particles
3. content of carbon and organic carbon

The possibility of identifying fine particles enhances air monitoring

Estonian Environmental Research Centre (EKUK) received a more up-to-date technology for executing air monitoring, which enables identifying fine particles in ambient air with more precision, which, in turn, improves the quality of executing air monitoring on the whole. Modernization of the equipment enables being prepared for monitoring responsibilities enforced in the coming years as well.

With the support from the Estonian-Swiss cooperation project, EKUK acquired a portable lab MARU (Mobile Aerosol Research Unit). Experience of similar Swiss and Finnish mobile labs was used to establish the laboratory and it was built in Estonia on the basis of a Volkswagen Crafter. MARU makes it possible to measure chemical composition of ultrafine particles (with circumference of less than 1 micrometre) in the air, fractional division of particles, and the content of carbon and organic carbon.

The implementation of the new portable laboratory improved the capability of Estonian national monitoring network in measuring aerosols, chemical composition of fine particles, and fractional division of particles. From now on, it is possible to achieve higher sensitivity (in terms of lower identification limits) of different indicators and larger number of identifiable parameters. This enables Estonia to solve issues related to the origin of particles and other air pollution and assess the health effects of air pollution more accurately. In addition, knowledge acquired as a result of the project make it possible to prepare action plans for improving ambient air concerning the origin of air pollutants.

Photo: Maarja Mitt

A portable lab MARU

The measurement campaign highlighted bottlenecks

MARU has already been implemented in several problem areas. In cooperation with the Paul Scherrer Institute (Switzerland), a measurement campaign "Identification of the chemical composition of atmospheric gases and

aerosols in Estonia" was conducted in 2014. During the campaign, Swiss scientists performed fine particle measurements in Tartu, Kohtla-Järve and Tallinn with the MARU measurement bus. Collecting data allowed them to assess the rate of fine particles resulting from the use of fossil and renewable fuels in city air. As a result of the measurement campaign, the air quality of these regions was assessed and the marker compounds characteristic for the region and origin of particles identified. For example, during the testing in Tartu, the presence of waste incineration markers was detected in the stove-heating region.

Modernized Lahemaa monitoring station

Within the Estonian-Swiss programme, additional monitoring tools were purchased for the Lahemaa background monitoring station and the existing portable measuring stations were equipped with particle group-composition analysers. In addition, the calibration centre was brought up to date with calibration devices of particle analysers. Modernization of the Lahemaa monitoring station enables executing responsibilities pursuant to the new monitoring strategy of the European Union. An automatic measuring system of soluble particles and gases manufactured in Switzerland was installed in the monitoring station, allowing to replace the former manual methods and lab analysis with automatic measurements with high temporal resolution. The modernized portable monitoring stations have been used to perform air quality measurements in several regions across Estonia, including Kehra, Pärnu, Osula, Kohtla-Järve, etc.

Better service for local governments

EKUK provides services for solving problems related to the quality of ambient air to all local governments across Estonia. EKUK assess the nature of the problem, introduces the valid pollution levels, as well as environmentally friendly ways of living and manufacturing, and offers research and solution methods.

Project 9

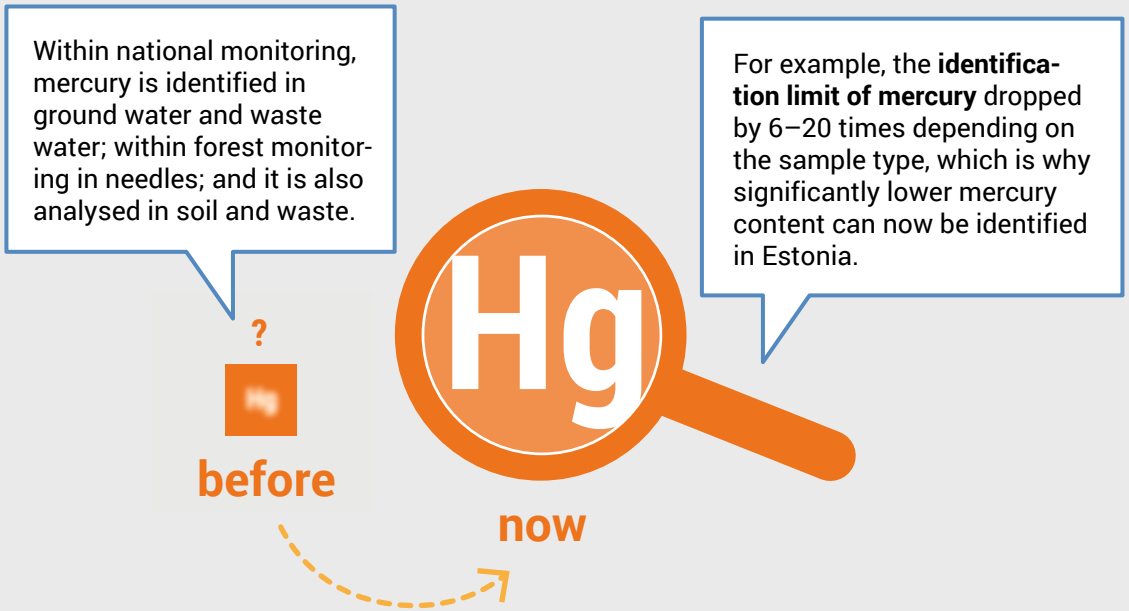
Increasing efficiency of environmental monitoring in Southern Estonia

GRANT RECIPIENT:
EESTI KESKKONNAUURINGUTE KESKUS OÜ

PROJECT DEADLINE:
October 2013

Total cost of the project	CHF 1,558,291	(1,286,164.12 euros)
Incl. Swiss support	CHF 1,324,547.35	(1,093,239.50 euros)
Incl. co-financing from KIK and EKUK (15%)	CHF 233,743.65	(192,924.62 euros)

Faster and prompter environmental status monitoring with the help of 34 new devices.



For example, new lab devices now implemented include the following:

1. inductively coupled plasma mass spectrometer
2. ion chromatographs required for identifying ions
3. liquid chromatograph
4. water treatment apparatus
5. mercury analyser
6. stereo microscope
7. optical microscope

Environmental monitoring is conducted with higher capability in South Estonia

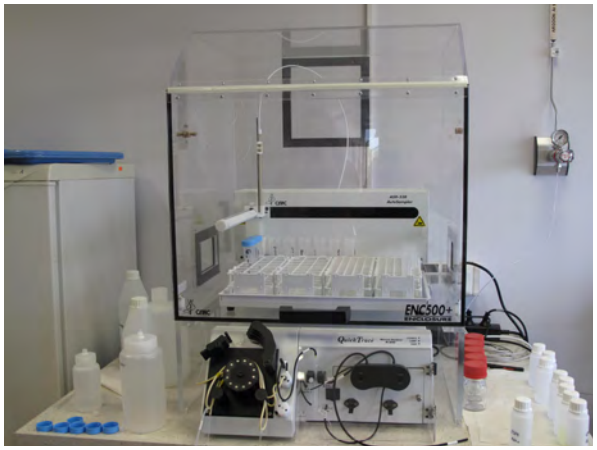
The South-Estonian environmental monitoring lab received a new selection of devices, which now enables receiving higher-quality indicators about the environmental status in the region in terms of both higher sensitivity and promptness than before.

In South Estonia, national environmental monitoring is performed by Estonian Environmental Research Centre (EKUK). In order to preserve and improve monitoring capability, quicken operation processes and lower the identification limits of definite indicators, the Tartu department of EKUK required modern lab equipment. New technology was also required for Estonia to be able to meet environmental monitoring requirements established by the national environmental monitoring and EU directives in a more efficient way.

The out of date technology was becoming an impediment in ensuring sufficient quality of monitoring data and the capability of environmental monitoring.

34 new devices

Within the Estonian-Swiss cooperation programme, the Tartu lab of EKUK received 34 new devices, supplied by Quantum Eesti AS. For example, the new lab devices include an inductively coupled plasma mass spectrometer, ion chromatographs required for identifying ions, a liquid chromatograph, a water treatment apparatus, a mercury analyser, a stereo microscope and an optical microscope, etc. With the help of the new devices, a higher sensitivity of different environmental indicators (lower identification limits) can be achieved.



A mercury analyser

A water treatment apparatus

Fotod: Maarja Mitt

A liquid chromatograph

For example, the identification limit of mercury dropped by 6–20 times depending on the sample type, which enables identifying significantly lower mercury contents in Estonia. Within national monitoring, mercury is identified in ground water and waste water; within forest monitoring in needles; and it is also analysed in soil and waste. Identification of low concentrations of this highly toxic and environmentally hazardous compound is very important, because it makes it possible to discover contamination in early stages. It is also important to identify mercury in water environment as well, because it accumulates in fish and eating fish with high mercury content is very harmful to human organism.

Quicker and prompter monitoring

With the help of the new selection of devices, data exchange became quicker as well, which makes monitoring prompter. All the acquired devices are equipped with automatic sample entry systems that enables employees to plan time more efficiently, prepare samples for analysis, etc. In conclusion, component analysis takes less time.

Due to the improved identification accuracy, monitoring data are more reliable and of higher quality. Therefore, Estonia is now able to better meet the requirements for identifying different indicators established in EU directives and international conventions. Enhanced environmental information quality and reliability facilitate making necessary decisions related to environmental protection activity and programme development. Contribution to planning new directions of activity of Estonian environmental strategy is also important. Higher capability of chemical analyses enables EKUK to expand the sphere of research activity and act as a reference lab in the areas of surface- and groundwater as well.

Regional importance

Many South-Estonian companies and residents address the Tartu department of EKUK for counselling and solving the environmental issues of their close surroundings. The centre explains the nature of the occurred situation, introduces valid pollution limits, but also environmentally friendly ways of living and manufacturing, and offers research and solution methods. The new modernized equipment provides EKUK with better opportunities to solve these problems with higher quality, improves availability of environmental information in the region, and thereby also the environmental awareness of its residents.

Project **10**

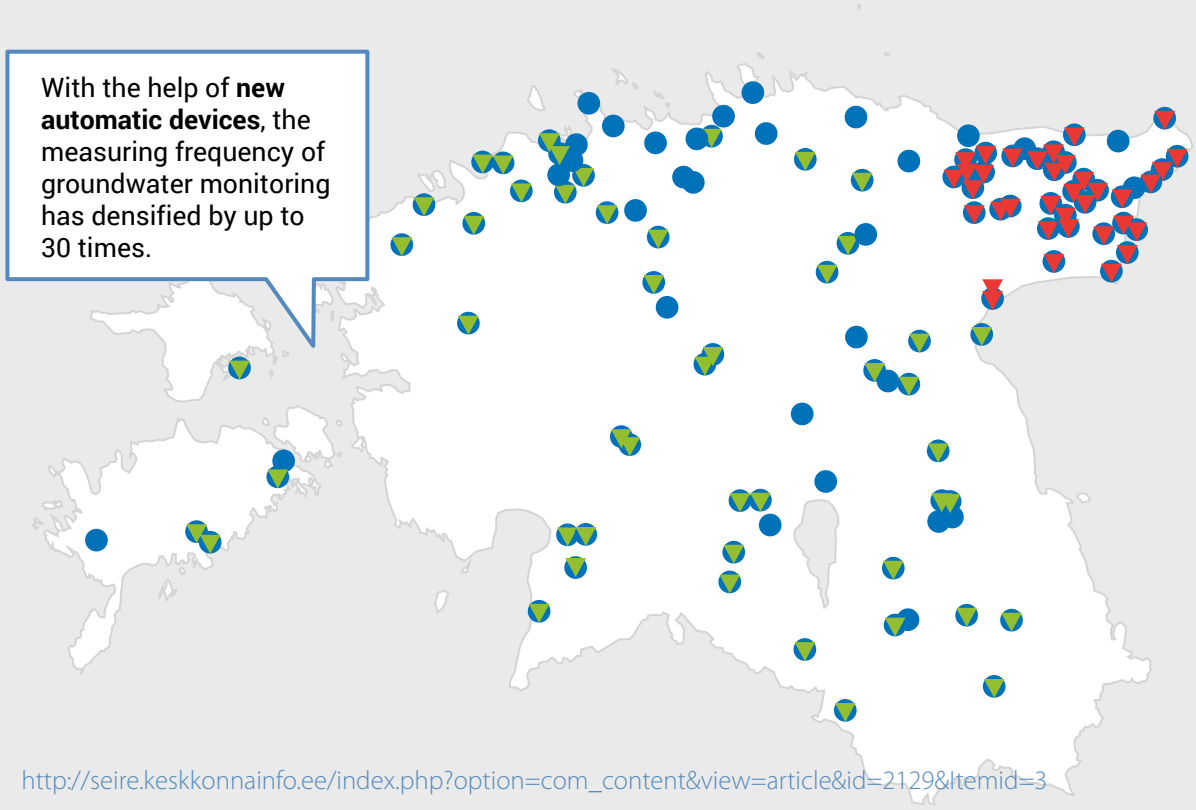
Development of sustainable groundwater monitoring system of Estonia

GRANT RECIPIENT:
MINISTRY OF THE ENVIRONMENT

PROJECT DEADLINE:
June 2013

Total cost of the project	CHF 143,143	(115,790.40 euros)
Incl. Swiss support	CHF 121,671.55	(98,421.84 euros)
Incl. co-financing from the state budget (15%)	CHF 21,471.45	(17,368.56 euros)

With the help of **new automatic devices**, the measuring frequency of groundwater monitoring has densified by up to 30 times.



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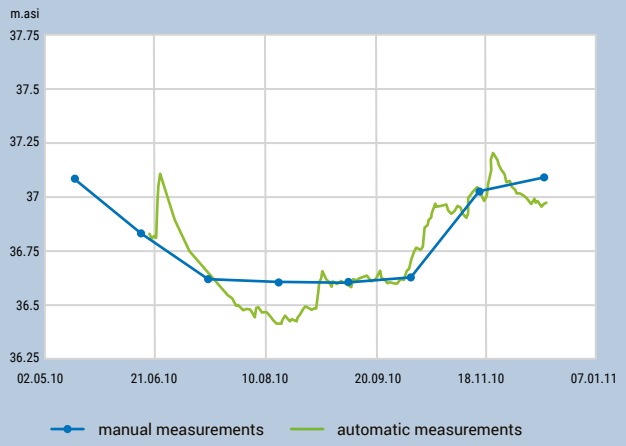


Level monitoring well

Automatic level meter (Norwegian project)

Automatic level meter (Swiss project)

The Estonian groundwater monitoring is more comprehensive and prompter than before

New automatic measuring devices were installed in the observation wells of Estonian groundwater monitoring, as a result of which, Estonia currently receives statewide operative information concerning the condition of groundwater as the main source of drinking water. The observation wells were equipped with measuring devices of water level, electric conductivity and atmospheric pressure.

The aim of national groundwater monitoring is to enable sustainable use of groundwater and assess the quality and suitability of groundwater as a source of drinking water. There are 39 bodies of ground water for observing the condition of Estonian groundwater, the quantitative and chemical condition is which can be observed with the help of the observation well network. Operative monitoring is performed in endangered or ill-conditioned bodies of ground water, and overview monitoring of the chemical condition is conducted in the remaining bodies of ground water. The objective of the quantitative condition monitoring of bodies of ground water is, in general, to describe changes occurring in the water level, while the aim of chemical condition monitoring is to discover pollutants found in groundwater.

The number of observation wells used for national groundwater monitoring across Estonia is 364. Before the project under the Estonian-Swiss cooperation programme, 102 observation wells were equipped with automatic measuring devices. However, this was not sufficient for guaranteeing a representative, reliable and operative data capture from bodies of ground water. In addition, data quality did not meet the expected level.

Enhanced coverage and denser monitoring

With support of the Estonian-Swiss cooperation programme, Ministry of the Environment acquired 86 automatic measuring devices with accessory devices required for their installation. The measuring devices were installed in 71 wells for groundwater monitoring. In 2012–2013, 47 groundwater level, 24

Sensor for measuring groundwater level and temperature

A device for programming groundwater monitoring sensors

electric conductivity and 15 atmospheric pressure measuring devices were installed. Locations of the new automated drilled wells were selected so that homogeneous monitoring information would be ensured of all bodies of ground water across Estonia. With the help of the new automatic devices, the measuring frequency of groundwater monitoring has densified up to 30 times. While before the groundwater monitoring frequency was 1–3 times per month, then now it is performed at least once a day. The information is now prompter and more reliable, and it enables better prevention of the possible worsening of the condition of bodies of ground water in both areas, where groundwater consumption is intensive, and in places, where manual measuring was performed less frequently thus far due to economic reasons.

Before, automatic measurements of the electric conductivity of water were only possible in 26 observation wells. The new automatic measuring devices enable to quickly determine the reasons for possible intrusion of salty water or other pollution in the groundwater layer. Pursuant to the European Union directives, one indicator of assessing the chemical condition of groundwater is namely electric conductivity.

Compliance with EU directives

Adding new parameters required for assessing the condition of groundwater enhances achievement of a higher quantity and better chemical condition of Estonian bodies of ground water. In addition, Estonian groundwater monitoring now complies with the requirements established by EU directives.

The higher-quality database is also a good material for preparing, executing and evaluating strategies, policies, measures, etc.

Monitoring information is available to all interested persons on the website of the sub-programme “Monitoring of bodies of ground water“ of action “Groundwater monitoring” of the national monitoring programme (http://seire.keskkonnainfo.ee/index.php?option=com_content&view=article&id=2129&Itemid=3).

Project **11**

Enhancing offshore monitoring capacities through the implementation of new technologies of the contact measurement

GRANT RECIPIENT:
TALLINN UNIVERSITY OF TECHNOLOGY, MARINE SYSTEMS INSTITUTE

PROJECT DEADLINE:
September 2014

Total cost of the project	CHF 315,494	(255,261.11 euros)
Incl. Swiss support	CHF 268,169.90	(216,971.94 euros)
Incl. co-financing from TTÜ (15%)	CHF 47,324.10	(38,289.17 euros)

The new technology increases the reliability of monitoring data analysis.

The following was acquired for offshore monitoring:

1 AUTONOMOUS WATER COLUMN PROFILER (buoy)

The buoy enables receiving long-term data in one point throughout the whole water column.

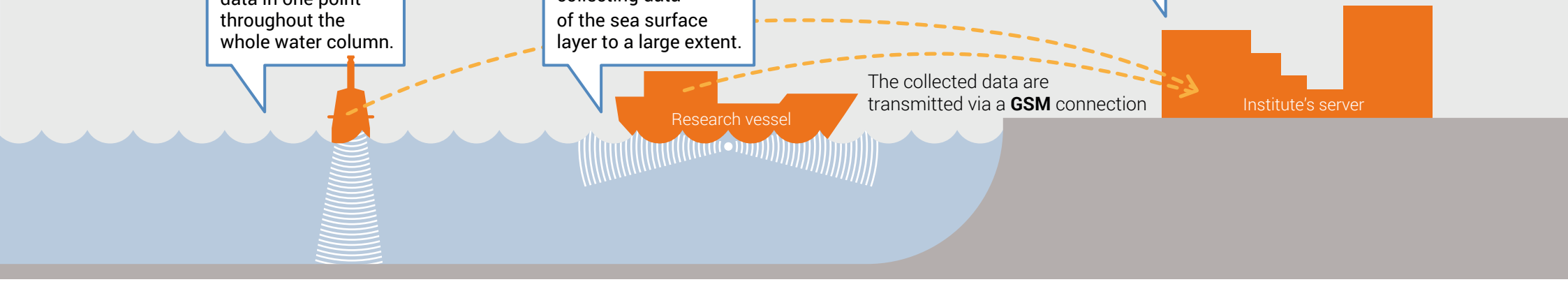
2 FLOW-THROUGH SYSTEM (FerryBox)

The flow-through system enables collecting data of the sea surface layer to a large extent.

Offshore monitoring frequency in terms of registered parameters increased approx. 10 times compared to the existing frequency.

Among other things, the new system registers the following:

- Sea water temperature
- Salinity
- Chl. a fluorescence
- Phycocyanin
- Turbidity
- Dissolved oxygen concentration
- Partial pressure of carbon dioxide (pCO_2)



The capability of Estonian offshore environmental monitoring was improved

The Marine Systems Institute of Tallinn University of Technology introduced new contact measuring technologies for offshore environmental monitoring, which improved the capability, promptness and reliability of Estonian environmental monitoring.

The European Union Marine Strategy Framework Directive establishes strict requirements for performing offshore monitoring in both the measured indicators and the frequency and extent of monitoring. Meeting these requirements with the classical monitoring methods used in Estonia before was very expensive. In offshore monitoring, autonomic measurements and water sampling from liners was implemented in Estonian offshore monitoring, but autonomic measurements from water column and sea regions off the liner routes did not exist. In addition, remote monitoring of the sea environment was performed, but reliability of results can only be ensured in case of a sufficient number of basic measurements.

Within the framework of the Estonian-Swiss cooperation programme, two contact measuring systems were acquired for offshore monitoring: a flow-through system placed on a research vessel (FerryBox) and an autonomous profiler of a water column (buoy). The new technology improved reliability of monitoring data analysis, which enables better forecasting of changes in sea regions, developing safety measures, and assessing their efficiency. In addition, the offshore monitoring frequency in terms of registered parameters increased by approx. 10 times compared to the existing frequency, which ensures a significantly bigger coverage with data in time and space.

Online transmission of data from the vessel to the office

The flow-through system placed on research vessel Salme (GO Systemelektronik GmbH) records different environmental parameters of sea water in the depth of 2 m, and transmits the collected data via GSM connection directly to the institute's server, where the data are available for saving in the environmental register. With the help of the new system, significantly more information can be received in space compared to typographic measuring. Among other things, the new system registers the temperature, salinity, chl. a fluorescence, phycocyanin, turbidity, dissolved oxygen concentration, and partial pressure of carbon dioxide (pCO_2) of sea water. Compared to buoys and other fixed platforms placed in the sea, a flow-through system is easier to maintain, receive high-resolution data in time and space, it is relatively green, and enables using the most modern sensors.

Flow-through system

Secondly, an autonomous profiler or buoy of a water column was installed in the Gulf of Finland in North-East of the Naissaar Island that records different environmental indicators based on sea water with the help of sensors. The buoy constructed by an Estonian company Flydog Solution works by the principle of probing. The probe moves up from the seabed in every 3 hours and performs probing from top to bottom in the depth of 2–80 meters. The probe is equipped with sensors that measure temperature, salinity, chl. a fluorescence, phycocyanin, turbidity, and dissolved oxygen concentration. The data are transmitted immediately after every probing via a GSM network in the institute's server for the use of specialists in both Estonia and the whole Baltic Sea Region. http://profilers.msi.ttu.ee/

Autonomic profiler of water column

More complete overview of open sea

Both the buoy and the flow-through system play an important role in offshore research. The buoy allows receiving long-term data in a single point throughout the water column. Based on these data, it is possible to study changes that occur in the water column over several months. The flow-through system enables collecting the data of sea surface layer to a large extent. The received data are used for producing sea forecasts, based on which, changes in the condition of the Baltic Sea can be analysed promptly in both time and space.

In order to perform Estonian offshore micro-waste monitoring, a Manta net (named by the largest ray fish species) and a stereo microscope were acquired as well. The net is attached to a vessel and can capture micro waste sized 1/3 mm. The captured micro waste is transported to a laboratory to study its composition under a special stereo microscope.

Manta net

Key Contributors

EESTI-ŠVEITSI KOOSTÖÖPROGRAMM
ESTONIAN-SWISS COOPERATION PROGRAMME

KIK ENVIRONMENTAL INVESTMENT CENTRE

Supplementory Contibutors and Beneficiaries

REPUBLIC OF ESTONIA
LAND BOARD

REPUBLIC OF ESTONIA
ENVIRONMENTAL BOARD

Eesti Maaülikool
Estonian University of Life Sciences

UNIVERSITY OF TARTU

TALLINNA TEHNIKAÜLIKOOL
TALLINN UNIVERSITY OF TECHNOLOGY

Eesti Teadusagentuur
Estonian Research Council

Eesti Geoloogiakeskus
Geological Survey of Estonia

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