Thanks to the quality of our healthcare, we are living longer but must also deal more with lifestyle diseases and chronic illnesses. The high costs of treating these are putting pressure on our healthcare system. Therefore, preventive healthcare – managing health and preventing diseases – is becoming increasingly important. To this end, the VITO Sustainable Health unit is developing applications, measurement methods and biomarkers.

“PERSONALISED HEALTHCARE IS THE FUTURE”

Rudi Torfs (Unit Manager)
Gert Otten (Program Manager)
Jef Hooyberghs (Program Manager)
Liesbeth Schrooten (Program Manager)
HOW CAN WE EASE THE PRESSURE ON OUR HEALTH CARE SYSTEM?

Rudi Torfs, Unit Manager Sustainable Health at VITO:
“When most people think of healthcare, they think of curative medicine. But the care lifecycle is much more extensive. A healthy lifestyle can prevent many health problems. Check-ups are also important: by establishing an early diagnosis or identifying risk factors, we can intervene earlier. Only after these preventive steps does curative healing come into play. This is followed by rehabilitation, which can be intense and prolonged, especially in patients with a chronic disease. By actively focusing on prevention, we not only improve the living standards of the patient, but we also reduce the pressure on our health care system.”

WHAT ARE VITO’S OBJECTIVES IN THIS AREA?

“VITO together with patients, government, the medical and pharmaceutical sector is searching for new healthcare solutions that fit in the context of preventive, participatory, predictive and personalised healthcare. These focus on detecting as many disorders as possible at an early stage. Treatments are tailored to the individual, in consultation with the patient. A personalised diagnosis and personalised treatment are adapted to each person and each health profile. VITO has a unique combination of expertise in this area. We have the technological knowledge needed to measure and analyse health factors, expertise in the biomolecular sciences, and a thorough understanding of the relationship between health, environment and lifestyle.”

WHAT SPECIFIC SOLUTIONS IS VITO DEVELOPING?

“VITO is active in various fields. Our research helps identify and validate new biomarkers, and develop new diagnostic tests. We are continuing to perfect these tests and improve the analytical capabilities of the equipment.

We develop sensor applications and devise measurement methods to evaluate environmental factors such as air quality. These techniques are used preventively to monitor environmental quality and take measures to improve that quality.

VITO also develops measurement methods to wear on the body. Portable sensors allow us to measure environmental factors and physiological parameters. We convert this information into data useful to doctors and patients, for example to allow for the refinement and personalisation of the treatment of serious chronic diseases. We develop applications that doctors can use to monitor their patients remotely and to refine the treatment based on the measured values.

Our research is also still used to support policy. We conduct air quality research, support the Flemish government in its policies on environmental health and environmentally hazardous substances, and contribute to the European directives on hazardous materials.”
\textbf{“RESEARCH INTO BIOMARKERS GETS A NEW BOOST”}

With the search for new biomarkers, VITO gives a boost to molecular diagnosis.

Previously, diseases were more often acute, and ended with the recovery or death of the patient. Today, however, we are faced with more and more chronic illnesses. P4 Medicine aims to confront this evolution: medicine is personalised, participatory, predictive and preventive. Treatments and medications are precisely tailored to the patient, and the patient is more involved in the treatment. By detecting diseases early, we can prevent complications and intervene before the disease manifests itself.

\textbf{BIOMARKERS}

Biomarkers are biological markers such as proteins and DNA in, for example, blood or urine samples that indicate the presence of a particular disease or give information about the stage of the disease. Program Manager Jef Hooyberghs: “Due to strict regulations and the development cost of clinical trials, too few candidate biomarkers find their way to diagnostic or therapeutic interventions for patients. Our research aims to change this. We have developed platforms in which all the expertise exists to detect new biomarkers. Today our research team is focusing primarily on the early detection of certain cancers.”

VITO is the technology partner in these partnerships. Jef Hooyberghs: “We develop algorithms to extract more information from the research data. The better the quality of the information, the higher the chance you will find new biomarkers. We do this with a specialised team of researchers with complementary backgrounds: biochemistry, analytical chemistry, biology, statistics, mathematics and computer science. We supplement this knowledge with the knowledge of hospital oncologists and pathologists. Last year, two patents were approved for our applications and we have applied for a patent for a new biomarker.”

\textbf{NEW POSSIBILITIES FOR DIAGNOSIS}

VITO is also investigating extracellular vesicles, which are nanoscale particles that allow cells in the human body to communicate with each other. These vesicles provide new opportunities for diagnosis, but various aspects remain unexplored. Due to their role in intercellular communication, researchers suspect that they also play a role in the transmission of certain diseases. Jef Hooyberghs: “The combination of biomarker research and nanotechnology makes the topic interesting for us. We have our own technologies to characterise nanoparticles as well as methods to identify biomarkers. Our added value lies in this combination.”

\textbf{STRATEGIC PARTNERSHIPS}

In our developments, we work closely with various stakeholders. University partners play an important role. In 2015, a framework agreement was concluded with Hasselt University, and VITO and the University of Antwerp (UA) strengthened their collaboration around the Centre for Proteomics. A common infrastructure is being developed with the UA specifically for mass spectrometry. This is being used for innovations related to protein biomarkers.
Connectivity in healthcare: patients are more involved in their treatment and doctors wish to intervene more quickly if something goes wrong. Connected health applications connect doctor and patient.

VITO’s connected health applications measure how air quality, the living environment and other health parameters change at times when patients are not in contact with their physician. As a result, physicians can intervene when the patient’s situation changes, for example by adjusting the medication or inviting the patient to an early consultation. This can often prevent the need for hospitalisation.

**Chronic Lung Patients and Air Quality**

VITO is testing an application that monitors air quality in patients with chronic bronchitis and chronic obstructive pulmonary disease (COPD). VITO concluded a cooperation agreement for this with CIRO, the Dutch centre of expertise for chronic organ failure. Patrick De Boever, project manager at VITO: “In the Netherlands, healthcare providers have a strong incentive to keep people out of the hospital. CIRO is therefore very interested in tools that can help in this. As a first step, we conducted mobile measurements of air quality in and around the centre of expertise. The focus was on black carbon, nitrogen dioxide and particulate matter.

**Retina Images**

Another diagnostic domain is retina technology. Patrick De Boever: “We take images of the different structures and blood vessels in the retina. Changes in the thickness or the branching pattern of the blood vessels give us information about the effect of lifestyle factors on our health or on systemic diseases and their evolution. We originally used the images to measure the acute effects of air pollution, but now we also include the detection of diabetes, heart disease and neurological diseases. This technology currently still requires rather large cameras. But we are looking for smaller, mobile cameras that produce images of sufficient quality and that we can more easily install in the patient’s home.”

VITO on one hand is trying to perfect the workflow so that a large number of images can be processed automatically. Patrick De Boever: “Mobile apps allow the images to be taken at the patient’s home. Thus we are taking the step from diagnosis alone to fully functional, connected healthcare applications.” On the other hand, VITO is looking for new characteristics of diseases that previously could not yet be detected via the retina.
In order to identify health problems caused by chemical exposure via the living environment and lifestyle, environmental health research was initiated in Flanders nearly 15 years ago. This has grown into a comprehensive centre of expertise coordinated by VITO.

To monitor the exposure of the Flemish to environmental pollution and chemicals, VITO is working with the Provincial Institute for Hygiene (PIH) and all Flemish universities within the Centre for Environment and Health. A programme is being developed and implemented there to monitor the effect of the environment on health in Flanders. In close consultation with policy-makers and local stakeholders, this data is translated into advice with which policy-makers can set up campaigns.

**“EFFECT BIOMARKERS CAN PREDICT INCREASED HEALTH RISK AT AN EARLY STAGE”**

Nathalie Lambrechts, researcher at VITO: “We are examining different age groups on the basis of human biomonitoring: adolescents, adults and previously also newborns. We analyse blood and urine samples from the participants for the presence of pollutants and the associated biological effects. Effect biomarkers are sensitive measurements and can predict an increased health risk at an early stage. The pollutants that we measure were selected in consultation with policy-makers and experts in environment and health. In the long term, we wish with this research to assess the extent of exposure to pollutants, and whether it has increased or decreased. We are also examining whether this is due to changes in the living environment, behaviour or specific policies.

In the region of Dessel, Mol and Retie we are currently performing follow-up health monitoring on 300 babies and their mothers. This is being done at the request of the Belgian Agency for Radioactive Waste and Enriched Fissile Materials (NIRAS/ONDRAF) and the partnerships STORA (Dessel) and MONA (Mol).”

**POLICY SUPPORT RESEARCH**

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VITO has developed special expertise in measuring air quality in the last 15 years, expertise that we place at the service of industry and government. VITO carries out air quality measurements and contributes to solutions that help businesses meet the legal standards.

A VITO air quality study takes place in three stages, says Gert Otten, Program Manager at VITO: “First, we measure the concentration of various substances and determine the quality of the air. Then we identify problem areas and try to locate the sources. Finally, we look for remedial measures: how can we reduce these emissions, preferably at the source, and ensure that they will not be a source of pollution in the future?”

OUTSIDE AIR

The general methodology for mapping air quality is changing: there is a trend toward low-cost, portable devices that collect a large amount of data, and allow volunteers and citizens themselves to perform the measurements. “The AirQMap.com application is a good example of this,” says Gert Otten. “We rent simple devices to cities and municipalities to measure local air quality. Employees or residents can then measure the air quality along predefined paths for three to four weeks. We then process all the data into clear colour maps. This allows our customers to know which streets or areas have the highest concentrations, and to adjust their actions accordingly.”

For larger, more complex studies, VITO uses stationary reference equipment. It measures the air quality continuously for several weeks. Weather data (wind direction, rain) help to interpret the data. VITO used this approach at Schiphol airport, and identified the level of ultrafine particles around the airport. At the request of the Flemish Environment Agency (VMM) and the Brussels Institute for Environmental Management (BIM), a similar study is being conducted at Zaventem airport. The results should indicate whether steps are needed to improve the situation.
INDOOR AIR

Pollution can also take place indoors, via construction materials and products such as furniture, fabric softeners and air fresheners. Thus manufacturers test their products thoroughly to ensure that they cannot harm the health of consumers. Gert Otten: “Products must meet certain standards, and companies are obliged and willing to carry out measurements and remediation to meet these standards. Silicone and adhesive manufacturer SOUDAL has entrusted its emission tests to us. We measure the volatile organic compound emission levels of products in special test chambers. We also verify that the products meet the relevant national and international regulations.

Manufacturers wish to distinguish themselves from their competitors with green labels. Our product emission tests help companies demonstrate the environmental performance of their products, construction materials for example, and obtain a label or certificate.”

VITO researchers also perform air quality measurements in schools, public buildings and office buildings in the industrial or service sector. VITO expertise is being used even in the Middle East. A project in Qatar focuses on the effect of specific materials and energy measures on air quality in schools.

NANOSAFETY TEST CENTRE

VITO air quality expertise is also relevant in the field of nanoparticles. Gert Otten: “Ultrafine nanoparticles can be released during manufacturing or in the daily use of products based on nanomaterials. VITO has set up a nanosafety test centre. Here we simulate specific steps in the production process, as well as the processing and use of products containing nanomaterials. This allows us to measure exposure levels of workers and users.”

In this unique VITO test centre, companies can study the safety and health aspects of their activities and include the results early in the design phase.

In this context, projects for several companies are in progress. VITO is also participating in the approved European consortium EC4safenano.
VITO has the know-how to measure the toxicological, chemical and biological properties of a substance and to assess whether it is safe enough to market. There are clear rules regarding the methodology used in this assessment. At the request of companies, VITO is conducting safety assessments, toxicity tests and characterisations to verify that the substances comply with REACH.
FREE OF ANIMAL TESTING

In the context of REACH, alternatives to animal testing are becoming more important. VITO has long been active in this area. VITO coordinated the CON4EI project for CEFIC. CEFIC needed a well-integrated system to assess whether a substance causes eye irritation. Several tests were carried out on a set of some 100 different chemicals. Gert Otten: “Our laser-based opacity meter, for example, tests the effect of chemicals on the transparency of the cornea using bovine eyes taken from slaughterhouse waste. The test kit we developed gives very good results and is much more accurate than previous tests. The cosmetic industry is already very interested.”

SAFETY BY DESIGN

Interest in renewable resources on the part of the research community, government and business is increasing. Biobased aromatics and new chemicals are being developed from biomass for example. Before these new substances are placed on the market, their safety properties must be known. Renewable substances must also comply with the European REACH legislation and be screened for safety. Traditionally the safety of a product is tested only when it is ready for large-scale production. However, VITO is working on methods to screen new substances and products at an early stage: safety by design. This enables us to know immediately whether a product is safe, before much time and money is spent on development. VITO is able to proactively apply its safety expertise in the design phase in order to optimise development costs. The pharmaceutical industry has been using this approach for some time, but it is gradually finding wider acceptance.

The VITO research is focusing on nanoparticles, among other things. VITO has the experience and technology to physically, chemically and biologically characterise substances to the nanoparticle level. If particles are not safe, their functionality can be adjusted to make them safer. VITO is involved in many European consortia that are focusing on the study of nanoparticles. Its expertise is among the best in Europe.