# Urine – Non-invasive Matrix in Human Biomonitoring

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*Urine is a non-invasive source of liquid biopsy samples and in addition, urine-based tests are more advantageous than clinicopathological parameters for periodic monitoring. We developed easy to use urine analyser system addressing the need for quantitative and costless multi-parameter urine analysis for both, relevant clinical environment as screening method, and at home as informative*

Evaluation and measurement of biochemical markers plays an important role in accurate diagnosis helping to adopt appropriate therapeutic methods that improves clinical outcomes. Clinically, urinalysis is crucial in the diagnosis and management of various diseases that are of either metabolic or systemic origin. Many disorders can be diagnosed in their early stages by detecting abnormalities in the urine [1]. These abnormalities include increased concentrations of constituents that are not usually found in significant quantities in the urine such as glucose, protein, red blood cells, ions, or changes in pH. Urine dipstick testing is typically performed as a point-of-care test, with interpretation of the results generally based on a vision-based colorimetric reaction, although newer automated systems for dipstick testing have been introduced.

CSEM is active since years in developing technologies to enable quick and quantitative urine analysis in different environments such as in hospitals (NUTRISHILD 2017), on-field camps (NIIDS 2019), at home (SUMIT 2021) or industrial environments (MIRA 2022). The proposed solutions were explored to tackle different necessities, specifically:

A point of care diagnostics for diagnosis and surveillance of diseases in refugee camps: A novel integrated diagnostic system for diagnosis and surveillance of diseases in refugee camps. Glucose, pH and sodium sensors have been developed and demonstrated good accuracy with a single calibration point.

- Personalized nutrition with a focus on lactating mothers and diet: A 6 channel electrochemical reader has been developed and coupled with screen printed electrodes for measuring pH in urine (Figure 1). Within the EU project Nutrishield, several analysers for different analytes have been developed to evaluate associations between the mother's milk composition and diet. The electrochemical reader enables measuring up to 6 urines in parallel with 50 uL sample volumes. No sample preparation is required, however a nL volume of additive is needed to regenerate the pH-sensitive surface of the electrode. More than 500 urines total from infants and mothers have been analysed and benchmarked with a commercial pH-meter showing a good accuracy. (Figure 2). The sensors can be use at least with 10 different urines without been recalibrated.
- Smart toilet for at home urine analysis: an add-on module to be mounted on any toilet bowl. A prototype of a urine sampling device has been made to collects urine from the toilet (Figure 1). The disposable sensing cartridges consist of 4 sensors for general health indicators and may be used for up to two weeks. It is planned to extend the cartridge with additional customer specific sensors. Good stability and accuracy have been achieved by using a single calibration solution for all the sensors, results related to sodium and glucose sensors are shown in Figure 3.
- Multisensor array: A miniaturized multi-sensor array for urine monitoring. Miniaturized, screen printed electrodes are tailored and functionalized for measurement in urine and other complex media. Sensors for the detection of harmful compounds and dysfunction markers with complex matrix compensation are combined in a single, digital dipstick. Machine learning is being used to train the sensor readout for more accurate and reliable sensors to improve upon commercially available semi-quantitative colorimetric urine dipsticks.

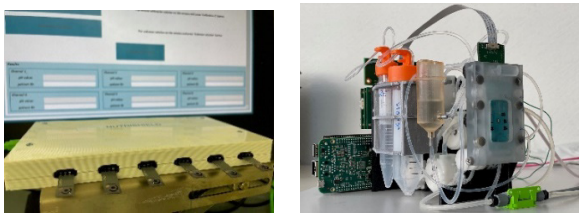

*Figure 1: Prototype devices developed in Nutrishield (left: 6 channel reader with pH sensors) and SUMIT (right: add-on module for urinalysis in toilets).*

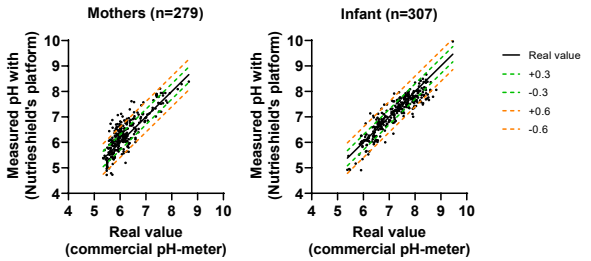


*Figure 2: pH measurements: mothers and infants urines measured with Nutrishield's device and benchmarked with a commercial pH-meter.*

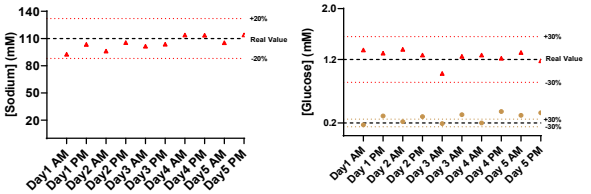


*Figure 3: Glucose and Sodium measurements performed along 5 days, twice per day, with the SUMIT's cartridge device and benchmarked with the standard Laboratory analysis.*

[1] E. W. Glissmeyer, E. Kent, J. Wilkers, J. E. Schunk, X. Sheng, A. J. Blaschke, C. L. Byington, Pediatrics 2014;133; e1121; 28; doi:10.1542/peds.2013-3291.