FeiSoLo-A low-cost particulate matter system

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1. Introduction

The increasing pollution of air by particulate matter (PM) is a global issue. More and more also in Germany. The "car city" Stuttgart (state capital of Baden-Württemberg) has already been called Germanys "Beijing". PM originates from a variety of sources e.g. farming, car traffic and industry and is harmful to human health [2]. The concentrations are determined by photometric and gravimetric methods. Because of the high cost of the standard gravimetric technique, the population of small cities is often not able to evaluate the concentration of PM [3]. The aim of this study is the analyze of the particulate matter situation in the city of Lörrach with new and low-cost PM-systems, that we developed ourselves.

2. Experimental Setup

For the determination of PM-concentration, a cheap and small SDS011 particulate matter sensor is used. The sensor is produced and calibrated by Novafit [1] and based on light-scattering photometry. Based on this sensor, WLAN-, mobile- and so called FeiSoLo (PM-Solar-LoRa)- modules were developed. The energy is provided by a solar system (So) and the data are sent by a LoRa communication (Lo) to an own public website [feisolo.org]. The sensors are installed in 20 different places in Lörrach, including busy roads and pedestrian zones. In addition a module was assembled in Stuttgart.

Fig 1: left: SDS011-sensor;right: developed PM-modules

Furthermore a laboratory setup was built, in order to analyze the sensor data with respect to different environmental factors (e.g. humidity, temperature) and to compare it with a much more expensive performance approved optical PM-sensor. To investigate the vertical profile of PM-concentrations weather balloon experiments have been performed.

Fig 2: PM-concentrations in Lörrach during four months

3. Results

So far, PM-concentrations during four months were recorded and analyzed (see Fig. 2). The analysis shows that the PM-concentration in the city of Lörrach has not exceeded legal limits yet, but we observed strong local variations. Surprisingly, sensors in higher altitudes detected larger concentrations, even though there was less traffic. Balloon measurements with our sensor confirmed the fluctuations of the concentration with altitude.

The analysis of the Stuttgart-module matched the data of a nearby officially gravimetric measuring station. Furthermore, different sources of PM could be analyzed, e.g. the PM-emission of a diesel passenger car. Fig.3 shows the PM-concentration during car driving under different conditions.

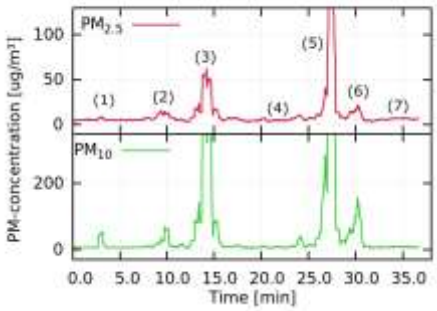

Fig. 3: PM-emission while driving with a diesel passenger car

It can clearly be seen that the PM concentration is increasing during a traffic jam (3) and high speed ride (5).

Conclusion

The FeiSoLo particulate matter system was developed and proved to be an effective and low-cost device to measure PM-concentration in all kinds of cities. By comparing our data with an expensive optical sensor and a legal gravimetric sensor we could show the reliability of the PM-measurements. In further experiments we will examine the effects of other natural influences e.g. various meteorological conditions and extend the FeiSolo-modules by means of NO_X-Sensors.

References

[1] http://aqicn.org/sensor/sds011/
[2] https://www.umweltbundesamt.de/themen/luft/luftschadstoffe/feinstaub
[3] Markus Klein, LUBW Karlsruhe, Germany