A novel sampling technique using a sediment collector (SECO) to collect particles from suspended matter in mine water with regard to long term monitoring

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Abstract

In the year 2018 active hard coal mining in Germany, which requires water drainage, will cease and so do the last two active coal mines. Since RAG Aktiengesellschaft (RAG) will shut down the active mining process, mine water pumping for safety reasons won´t be necessary anymore and RAG has the opportunity for flooding in these areas. Nevertheless in some former mining areas mine water needs to be pumped for the next decades. RAG has to face major challenges regarding pumping technique for mine flooding, monitoring and reduction of environmental impacts caused by mine water. Different substances in mine water of either natural or anthropogenic origin can potentially influence the quality of surface water (Denneborg et. al. 2017). To quantify the impact of mine water on surface water a sampling technique is needed.

Since most of the organic substances in mine water are particle bound, a reliable, continuous and low cost sampling process for suspended matter is needed. One method accepted by the authorities is a sediment collector (LAWA-Expertengruppe „QHF" 1996, OGewV 2016). This article gives an overview of the challenges by transferring a standard monitoring method for surface water to an aggressive medium such as mine water. Furthermore effects of continuous monitoring in contrast to spot sampling with the centrifuge will be investigated.

Keywords: Monitoring, Sampling technique, Suspended matter, Water treatment, Mine Water, PCB, SECO

Introduction

In the year 2018 active coal mining in Germany will end. The last two active coal mines are managed by the RAG and will be shut down by the end of 2018. At the moment a huge amount of water is pumped from over −1000 mNN depth into surface waters to keep the mines dry. After a transition period for leaving the mines certain areas will be flooded. The positive side effects are that the pumped water volumes and the impact on surface waters will be reduced.

This is important because industrial residues which contained dioxins and furane were used for backfilling of voids. Certain substances were bound in concrete and used for construction in the mine. In addition for safety reasons, non-inflammable hydraulic liquids were used. Some ingredients are now known as toxic for example polychlorinated biphenyls (PCB). Due to leakage, certain areas can contain PCB. During the mine flooding process, mine water could get in touch with those areas and a resolving process of toxic compounds is possible.

Since most of those organic compounds are particle bound, concentrations were very small in mine water. This is why suspended matter in mine water needed to be collected.

A standard sampling technique to gather suspended matter is the centrifuge. RAG started a monitoring program in cooperation with the office for environmental protection (LANUV) to detect the amount of suspended matter in mine water. During a monitoring program in 2015 and 2017 problems with the sampling method centrifuge occurred, caused by the aggressive medium mine water. Several sealings needed replacing after a single day of sampling. This was in strict correlation to the high salt content of mine water up to 80.000 mg/L, which resulted in high maintenance costs after one single sampling. In addition there was a difference between active and closed mines regarding the amount of suspended matter in pumped mine water. At some plant sites, mainly the closed mines, sampling with the centrifuge didn´t collect enough suspended matter for analytics. Because of those reasons a resistant, long term period and cost effective sediment collector (SECO) should be tested.

As you can tell from Figure 1 the SECO was installed at five different locations, with different mine water compositions. Those were selected to represent two categories of mine water. Either the impact of mine water drainage of an active or closed mine on the surface water was evaluated. Therefore the last two active mines Ibbenbüren and Prosper Haniel as well as the closed mines Haus Aden, Zollverein and Walsum were selected. According to the different locations a variety of different mine water compositions with high salt concentrations and/or different loads of particles and sizes were given.

Materials and Methods

Since the mid-nineties the sediment collector with two chambers is a standard method to collect suspended matter from surface water (LAWA-Expertengruppe „QHF" 1996). The novel approach of RAG and LANUV is a continuous collection of suspended matter from the corrosive medium mine water. Adaptations were necessary to use this collector in mine water.

An improved sediment collector with three compartments is used to gather as

Figure 1: *Five Locations including active and closed mines with a sediment collector*

much sample material as possible. This is due to the amount of suspended matter, which can vary with the sampling point. With this adaption longer sampling periods can be tested, in contrast to single measurements with the centrifuge.

The SECO consists of a special plastic which is resistant against corrosion caused by salts. To guide the medium through the collector, several baffle plates were installed as shown in Figure 2.

To use the effect of sedimentation, the flow velocity is highly reduced by expanding the diameter of the flow channel in the chamber relative to the inlet pipe. Due to the reduction of flow velocity the suspended matter, symbolized by black dots in Figure 3, can sink down and be collected from trays.

To ensure stable operating conditions and to avoid varying flow velocities a flow control was installed and a flowmeter to measure the actual flow. This is necessary since the SECO operates best within flow velocities from 5 to 10 l/min. This also means it needed to be installed in bypass to the mine water mainstream. Furthermore the flowmeter is used to get the correlation to mine water volumes to identify the particle ratio see Figure 6.

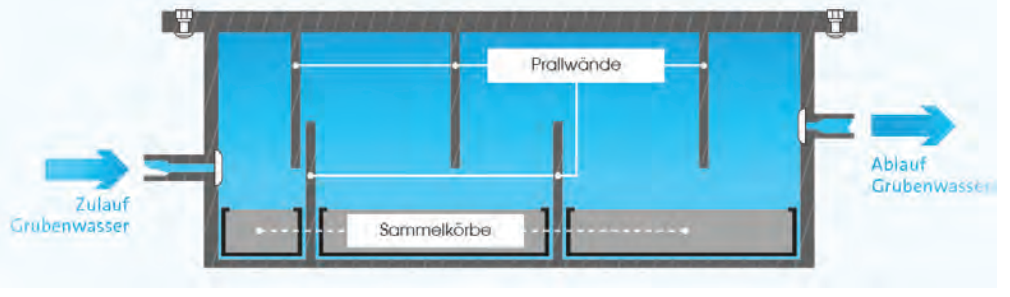

Figure 2: Technical set-up sediment collector (SECO)

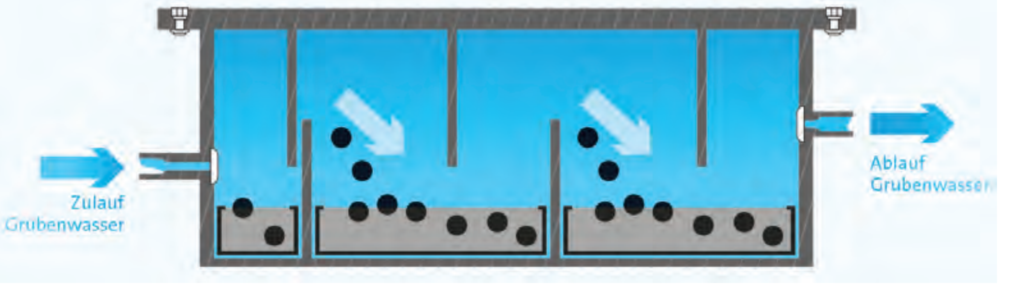

Figure 3: Sedimentation process in SECO

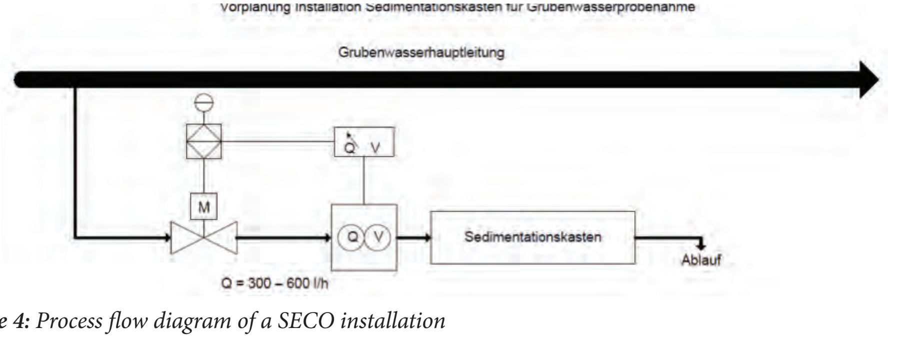

Figure 4: Process flow diagram of a SECO installation

Figure 5: Locations with installed SECO

According to the sampling points different installations had to be build. To avoid damages caused by rain or snow, the SECO and its environment was either protected by an isolation housing or if necessary installed in a container (see Figure 5). Beyond that the SECO required protection against vandalism, since some sampling points were located on public ground.

After four to twelve weeks of sampling an independent laboratory characterized the collected particles (Figure 6) concerning their amount and chemical composition. In addition the particle size distribution was determined. Results regarding PCB were compared to the corresponding results from suspended matter collected with the centrifuge.

Results

At five different plant sites, the sediment collector was able to capture suspended matter from aggressive mine water. Degrading effects to the synthetic housing material were not given. The sampling period, to collect enough matter for analysis, is highly depend-

Figure 6: Collecting suspended matter

ing on the investigated mine water and takes from four to twelve weeks as you can see in Table 1.

At all sites PCB were detected in the suspended matter during the first measurements. Several results for Ibbenbüren and Prosper Haniel are present and comparable. Exemplary results are stressed at the active mine Prosper Haniel. It could be shown that a correlation from the results of the SECO to the centrifuge

Table 1. Sampling periods

Location	Sampling period
Ibbenbüren	Sampling period
Prosper Haniel	6 weeks
Haus Aden	4 weeks
Zollverein	12 weeks
Walsum	8 weeks
	12 weeks

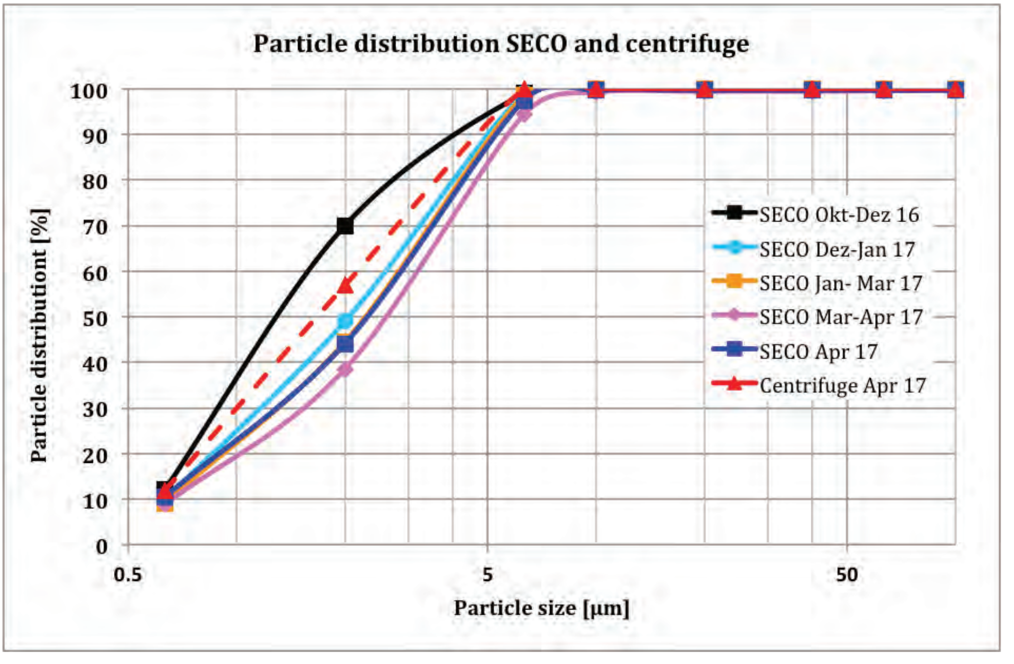

***Figure 7:** Comparison of particle distribution SECO and centrifuge*

was given (Figure 7 Rahm 2018). Both sampling techniques proofed to be abled to collect particles smaller than 63 µm. This was important for this investigation since organic matter like PCB can be found in this fraction.

As you can tell from Figure 8 (Rahm 2018) the solid content of PCB in collected suspended matter are comparable. PCB which were typically used in mining hydraulic liquids, meaning PCB 28 and PCB 52, were identified in all samples. The SECO enables long term integrative monitoring to accumulate suspended matter. This obviously takes a longer period to gather the same amount of suspended matter compared to the centrifuge. The SECO can collect for months without degrading effects to housing and without operating costs caused by an operator.

One side effect of this process while surveying water qualities at a high standard level is minimized costs. In comparison to the centrifuge the costs of invest are roughly 10 times smaller. Furthermore once installed the SECO is not as cost intensive as the centrifuge which needs an operator at all times.

Conclusion

The SECO is a reliable and comparable long term monitoring technique to collect particles from suspended matter in an aggressive medium such as mine water. It shows comparable results to the standard sampling method with the centrifuge and is not as cost intensive.

Process development took several steps. First the SECO was installed in free flowing

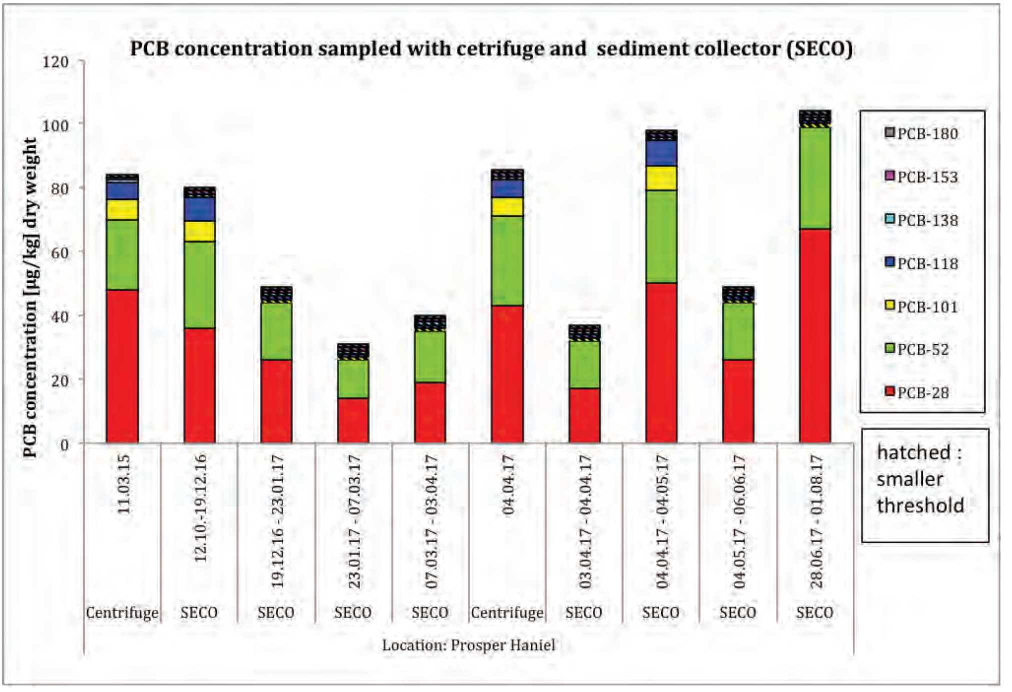

Figure 8: *PCB concentration in suspended matter sampled with centrifuge and SECO*

water than at a pipeline and in the end in a bypass of a high pressure mine water pipeline. The lessons learned can be read as follows.

1. Variation in water pressure caused pressure peaks hence a pressure relief valve needed to be installed. Maximum pressure is 0,5 bar, otherwise the SECO will burst.
2. The SECO needed to be resistant against cold temperatures and vandalism, so special housings and insulations were installed.
3. In high mineralised mine water the operating pump for the SECO needs to be replaced after three months, due to corrosion.
4. Depending on the sampling location, periods of four to twelve weeks were necessary to collect enough suspended matter for analysis.
5. With regard to installing, operating and maintaining the SECO is more stable than the centrifuge. Furthermore the SECO has proven to resist aggressive mine water in contrast to the centrifuge. Finally the SECO shows advantages with regard to costs.

In all industrial applications in which a continuous monitoring of suspended matter in harsh conditions is important, i.e. salt mining and ore mining, the sediment collector could be an appropriate sampling technique.

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