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Forsmark site investigation

Control of microorganism content in flushing water used for drilling of KFM02A and KFM04A

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Abstract

A system for disinfection of flushing water and continuous dosage of tracer for drilling fluids has been developed. It comprises an ultra violet (UV) radiation unit, a carbon filter for reduction of high total organic carbon content in drill water and a flow controlled dosing pump attached on line in the flushing water system. In this study, carbon filters were excluded and the UV-chamber was repositioned. Continuous dosage of tracer for drilling fluids was employed, which reduced the demand for storage tanks significantly.

There was some improvement in lowering the microorganism numbers during 2003 compared to the data obtained 2002. In particular, the removal of storage tanks reduced the peak in cultivable microorganisms obtained in tanks left over weekends. However, it became clear that the water after the UV-unit is not sterile.

It is recommended that rinsing procedures for the tubings and tanks in use are developed. Those procedures should be applied before every new drilling campaign. Confirmation of the procedures for control of proper UV-efficiency must be performed and it should be made clear that the drilling fluid trace solution is kept clean with low microbial numbers. It should not be stored for prolonged periods.

Sammanfattning

Ett system för TOC reduktion och anti-mikrobiell behandling av spolvatten för borrning har utvecklats. Systemet omfattar ett kolfilter och en UV-enhet ”in line” på spolvatten-systemet. Resultat från den första undersökningen av systemets effektivitet visade på nödvändigheten av att UV-desinfektion sker så nära borr-riggen som möjligt. Lagring av borrvatten över dag eller helg i tank samt dålig returspolning av kolfilter gav förhöjda bakteriehalter i spolvattnet. UV-enheten fungerade dock som planerat, men den satt felplacerad i systemet. I denna undersökning användes inte kolfilter och UV-kammarens position flyttades. Samtidigt infördes kontinuerlig dosering av spårämne vilket reducerade behovet av lagringskapacitet avsevärt.

Antalet mikrober var lägre under 2003 jämfört med 2002. Avlägsnandet av stora lagrings-tankar minskade det höga antalet odlingsbara bakterier efter lagring. Spolvattnet innehåller emellertid fortfarande relativt höga halter mikrober efter UV. Det kan ha flera olika enskilda eller samverkande orsaker. UV-enheten är smutsig eller har en dålig lampa, ledningar, rör och kranar är dåligt eller aldrig rengjorda. Slutligen kan det finnas mikrober i spårämnes-lösningen.

Procedurer för rengöring av rör, slangar och tankar som kommer i kontakt med borrvattnet bör utveckas. UV-enhetens effektivitet bör konfirmeras. Slutligen skall man kontrollera att spårämneslösningen är fri från mikrober.

Contents

1 Introduction

This document reports performance of and results from control of microorganism content in flushing water used for drilling of KFM02A and KFM04A. The work was conducted according to activity plan AP PF 400-03-09 (SKB internal controlling document).

A system for disinfection of flushing water and continuous dosage of tracer for drilling fluids has been developed. It comprises an ultra violet (UV) radiation unit, a carbon filter for reduction of high total organic carbon content in drill water and a flow controlled dosing pump attached on line in the flushing water system. It is known since earlier investigations that flushing water may introduce large number of contaminating microbes into the aquifers /Pedersen et al, 1997/. This should be avoided.

A first control study demonstrated that storage of flushing water over weekends, and insufficient return flushing of carbon filters in use resulted in increased numbers of micro-organisms, compared to fresh flushing water from the source /Pedersen, 2002/. The UV unit worked as planned but was not positioned optimally. In this study, carbon filters were excluded and the UV-chamber was repositioned. Continuous dosage of tracer for drilling fluids was employed, which reduced the demand for storage tanks significantly. An over-view of the flushing water support during drilling of KFM02A and KFM04A is given a in the Appendix (the design of the flushing water support was identical in the two boreholes).

2 Objectives

- This activity aimed at controlling the performance of the re-constructed flushing water treatment system with reference to its ability to kill potentially occurring microbes in the flushing water.
- The results should demonstrate significant decreases in the number of cultivable microbes along the flushing water line, from the flushing water borehole source to the water entering the drilling machine.

3 Equipment and performance

Standard cultivation equipment and procedures were employed as follows:

Total numbers of microorganisms were analyzed in triplicates according to /Pedersen and Ekendahl, 1990/, using acridine orange direct counts.

Numbers of cultivable microorganisms were analyzed in duplicates according to /Pedersen et al, 1997/, with R2A medium.

Most probable numbers of sulphate reducing bacteria were analyzed according to /Haveman et al, 1999/.

Sampling was performed in 1 L sterile bottles on 2 positions in the drill water line, before and after the UV-unit. Tubings were disconnected for sampling when valves were missing. Sampling was preformed 030305 during drilling of KFM02A and 031014 during drilling of KFM04A

4 Results

4.1 Total number of microorganisms

Figure 4-1 shows the pooled total numbers of microorganisms during the two measuring occasions, in comparison with data from drilling the KFM01A, 021010 /Pedersen, 2002/. The total numbers were comparable over all three measuring occasions. A slight decrease after UV was observed 030305. UV-killed microorganisms can still be visible as total number some time after sterilization. It is, therefore, not expected that the total number of microorganisms will decrease more than marginally, and this was also the case.

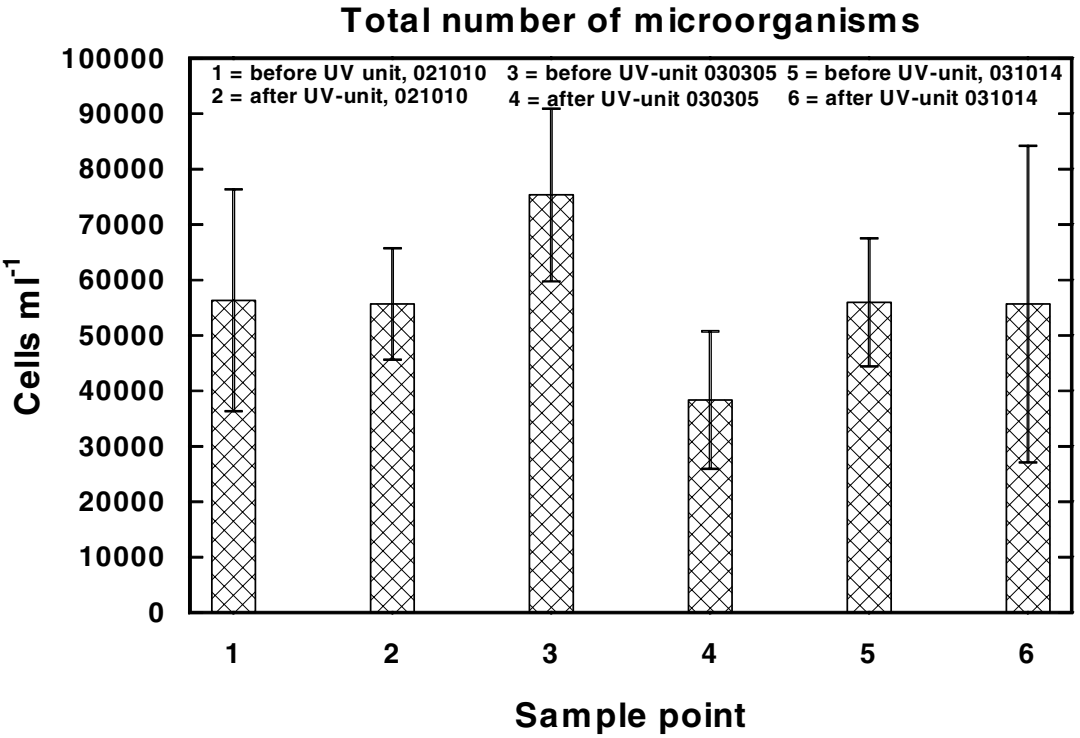

Figure 4-1. *Total number of microorganisms. Bars indicate standard deviation for three independent measurements.*

4.2 Number of cultivable microorganisms

The numbers of cultivable microorganisms were low after the UV-unit 021010, but were higher after UV 030305. At the last sampling occasion (031014), the number of cultivable microorganisms was lower after the UV-unit. UV treatment should reduce or preferentially totally kill cultivable microorganisms. Ideally, there should be no, or very low counts after a UV treatment. This was not the case here, see Figure 4-2.

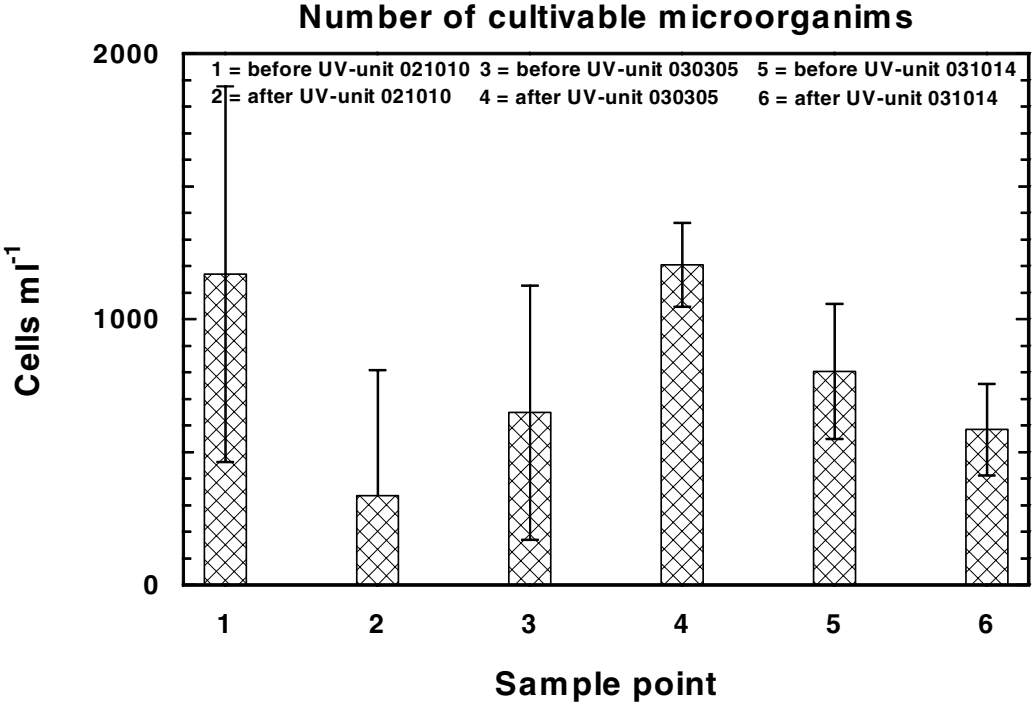

Figure 4-2. *The numbers of cultivable microorganisms. Bars indicate standard deviation for two independent measurements.*

4.3 Sulphate reducing bacteria

Sulphate reducing bacteria were not detected at any sampling point.

4.4 Variability over time 1 and time 2

Two sampling times were applied at each sampling occasion. This was done to assay the variability in time and sampling procedure. Figure 4-3 shows the results. There was a limited variability at most sampling occasions, possibly with exception for data before UV-unit 030305 and 031014. This may indicate contamination due to particles or dirt in, or close to the sampling valve.

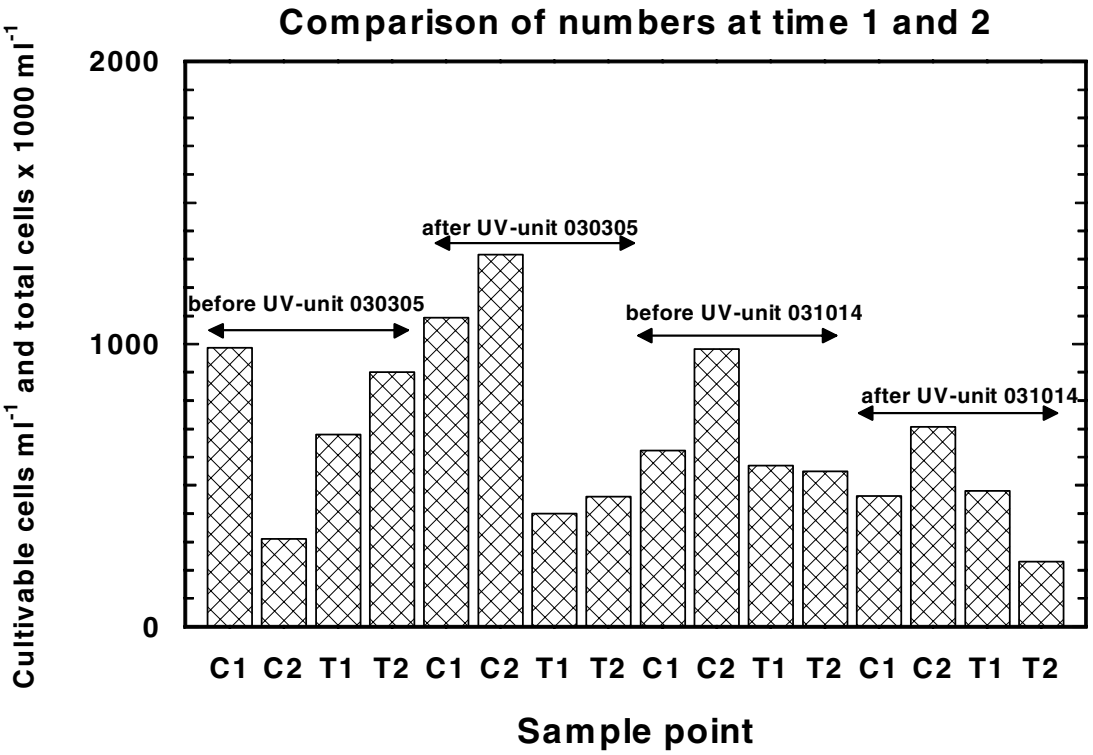

Figure 4-3. *Variability in data as distributed over sampling times 1 and 2. T represents total number and C represents cultivable numbers. 1 and 2 represent sampling time 1 and 2.*

5 Conclusions and suggested improvements

There has been some improvement in microorganisms numbers during 2003 compared to the data obtained 021010. In particular, the removal of storage tanks reduced the peak in cultivable microorganisms obtained in tanks left over weekends. However, it becomes clear that the water after the UV-unit is not sterile. This can be due to low UV-efficiency. It is important that the quarts glass tubes for the UV-lamps are kept clean and that the UV-lamps are in operation at their designated effect. Finally, the flow rate during sampling must not exceed the maximum flow rate for the UV-unit. This can possibly be achieved by installing valves that allow flow rate controlled sampling.

Another possibility is that the tubings, tanks etc. downstream the UV-unit/tracer addition is dirty or not well rinsed and washed. It is important to note that UV-treatment is only efficient in the UV-unit. The system must be clean downstream to maintain a good disinfection effect from the UV-unit. Preferably, all tubings should be washed using high pressure steam and finally washed with a disinfecting solution. Chlorine dioxide or chlorine can be used. Those chemicals can be washed out before drilling. Finally, the drilling tracer solution must be kept free from microorganisms.

Recommendations

- Install valves for rinsing and sampling procedures.
- Develop rinsing procedures for the tubings and tanks. Those procedures should be applied before every new drilling campaign. Use chemical disinfectants for disinfection and cleaning.
- Confirm that the procedures for control of proper UV-efficiency are appropriate and that they are followed.
- Make sure that the drilling fluid trace solution is kept clean without microorganisms. Do not store this solution for prolonged periods and mix tracer with sterile water in sterile tanks. This can be achieved by treatment with a disinfectant.

6 References

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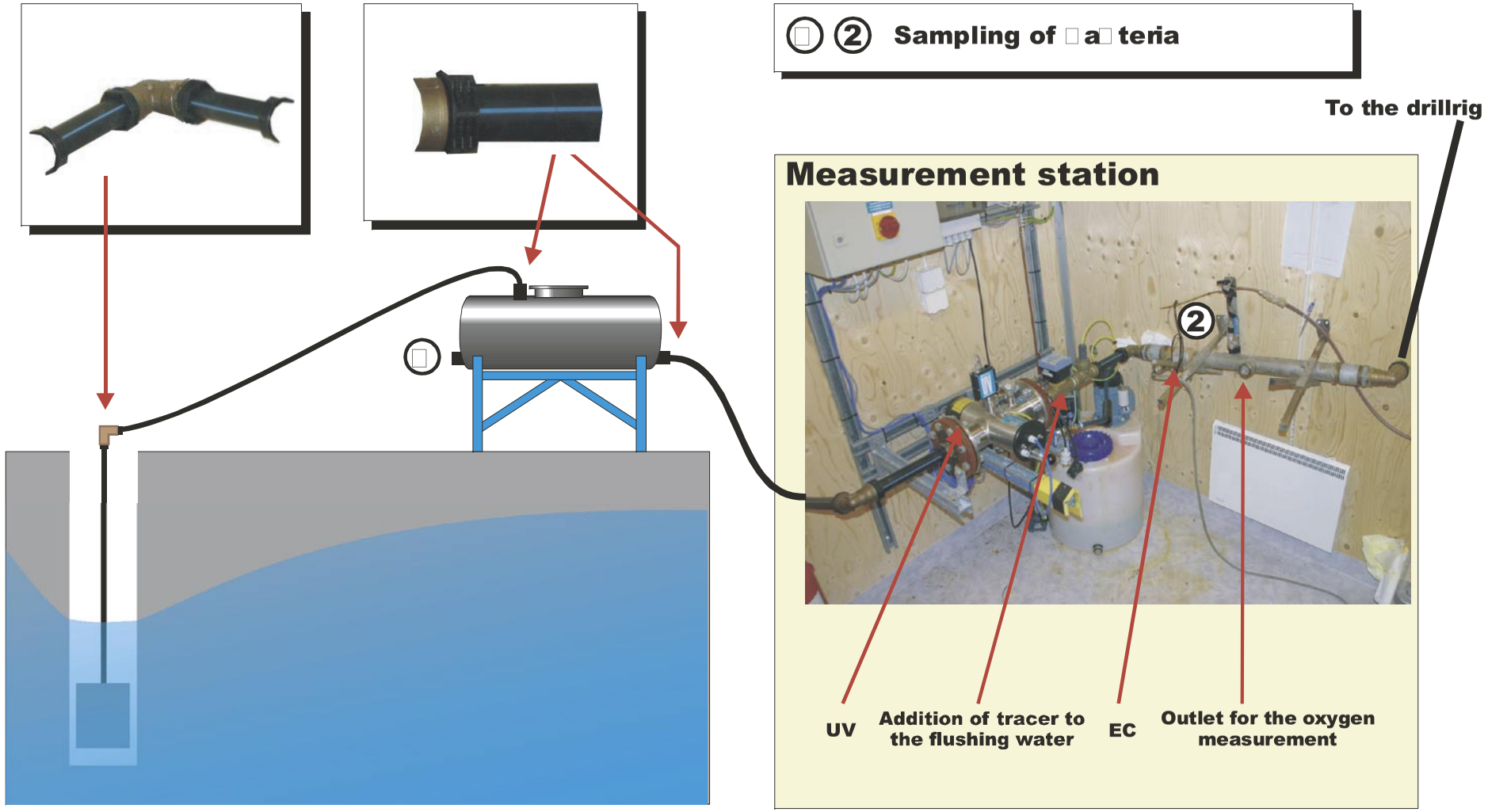

Figure A1-1. *Flushing water support during drilling of KFM02A.*