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Oskarshamn site investigation

Control of microorganism content in flushing water used for drilling 2003-11-25

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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 and a flow controlled dosing pump attached on line in the flushing water system. The continuous dosage of tracer for drilling fluids that was employed reduced the demand for storage tanks significantly.

The numbers of cultivable microorganisms decreased after the combined UV-unit and the tracer dosage point but increased downstream this point along the drill water line. The last sampling point, at the drill rigg, exceeded the number of cultivable microorganisms before the UV-unit, indicating a contamination source within the drill water line.

It is recommended that rinsing procedures for the tubings and tanks in use are developed. Valves for cleaning and sampling must be installed. Cleaning 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 without microbes. Mixing with sterile water would be an advantage. It should not be stored for prolonged periods

Sammanfattning

Ett system för desinfektion av spolvatten och kontinuerlig dosering av spårämne till spolvattnet har utvecklats. Det består av en ultraviolett lampenhet och en flödeskontrollerad doseringspump som kopplats in på spolvattensystemet. I denna undersökning användes kontinuerlig dosering av spårämne vilket reducerade behovet av lagringskapacitet avsevärt.

Antalet odlingsbara mikroorganismer minskade efter UV och doseringsenheten, men ökade efter denna punkt i spolvattenlinjen. Vid sista provpunkten, vid borr-riggen, översteg antalet odlingsbara mikroorganismer det antal som uppmättes före UV-enheten. Det betyder att en föroreningskälla finns inom spolvattensystemet.

Procedurer för rengöring av rör, slangar och tankar som kommer i kontakt med borrvattnet bör utveckas. Kranar för provtagning och rengöring måste monteras. UV-enhetens effektivitet bör konfirmeras. Slutligen skall man kontrollera att spårämneslösningen är fri från mikrober. Det är viktigt att spårämnet blandas i sterilt vatten i steril behållare.

Contents

1 Introduction

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 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; Pedersen, 2002/. This should be avoided. The continuous dosage of tracer for drilling fluids that was employed reduced the demand for storage tanks significantly.

2 Objectives and scope

- This activity aimed at controlling the performance of the flushing water UV-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:

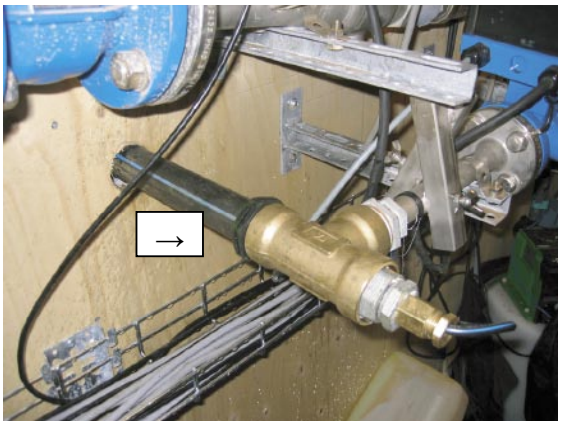
Total numbers of microorganisms were analyzed in duplicates according to /Pedersen and Ekendahl, 1990/, using acridine orange direct counts.

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

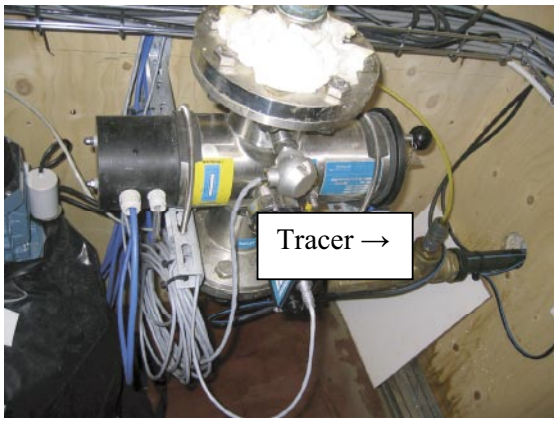
Most probable numbers of sulphate reducing bacteria were analyzed according to /Haveman et al, 1999/.

Sampling was performed in 1 L sterile bottles on 4 positions in the drill water line as depicted in Figure 3-1. Tubings were disconnected for sampling when valves were missing.

All sampling was repeated once, giving two independent sampling times.

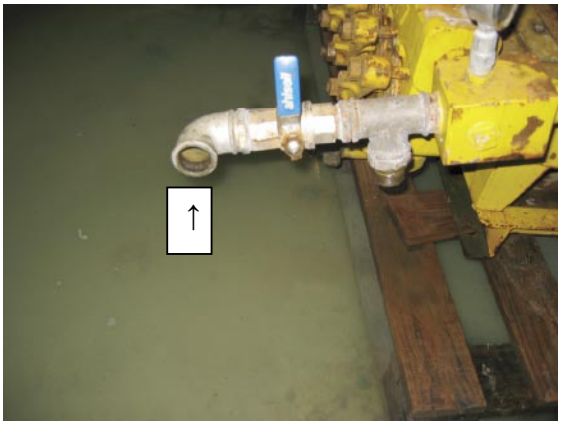


A. Sampling point (1) before the UV-unit.

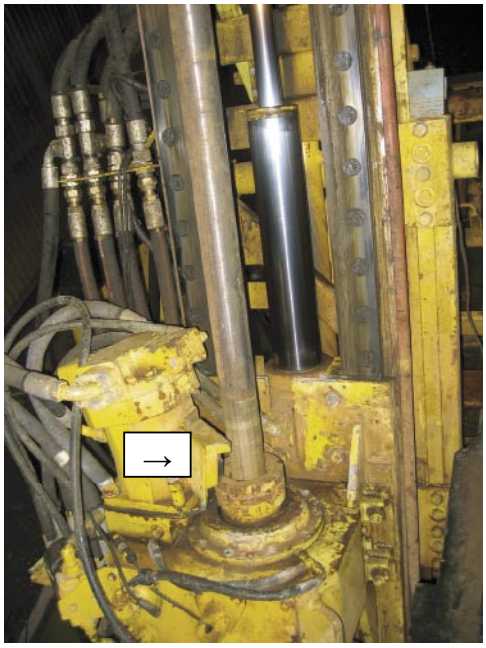


B. The UV-unit and the point of tracer addition.

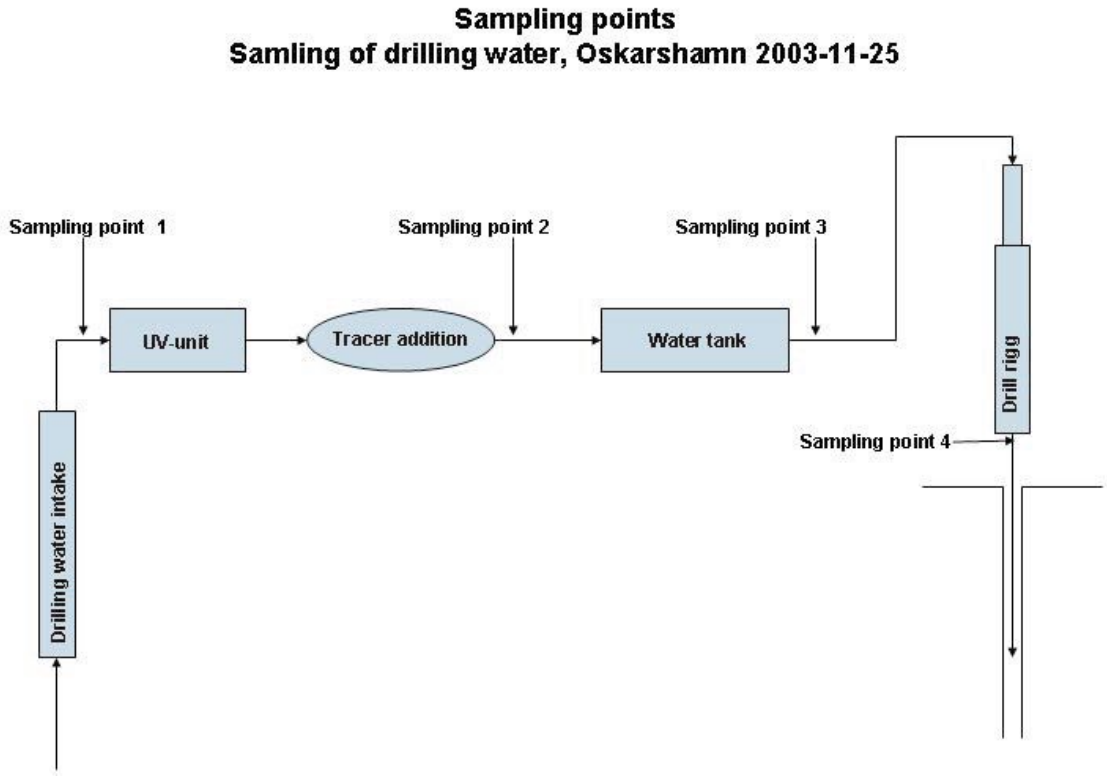
C. Sampling point (2) after UV-unit and tracer addition.



D. Sampling point (3) after the tank.



E. Sampling point (4) at the drill rigg. The drill string was lifted and water was sampled



F. Schematic drawing of the drilling water system and the sampling points.

Figure 3-1A-F. *Sampling points.*

4 Results

4.1 Total number of microorganisms

The total numbers of microorganisms decreased somewhat after the UV-unit (Figure 4-1). UV-killed microorganisms can still be visible as parts of the total number some time after sterilization. It is, therefore, not expected that the total number of microorganisms will decrease more than marginally after the UV-unit, and this was also the case.

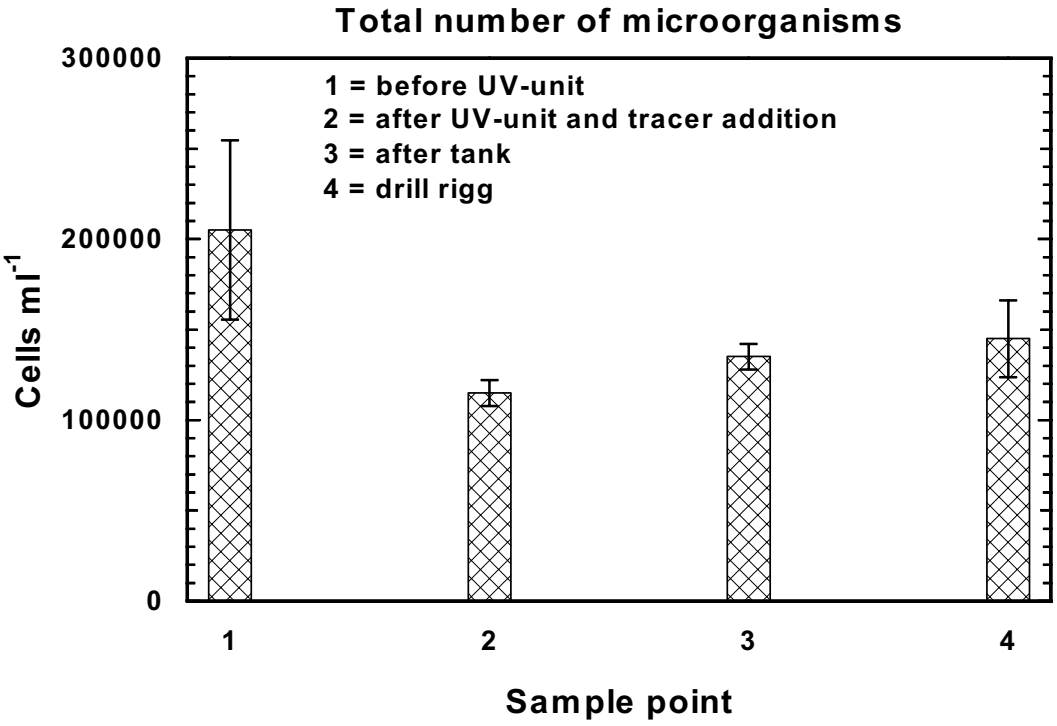


Figure 4-1. *Total number of microorganisms. See Figure 3-1 for positions of the sampling points. Bars indicate standard deviation for two independent measurements.*

4.2 Number of cultivable microorganisms

The numbers of cultivable microorganisms decreased after the UV-unit but increased downstream the drill water line (Figure 4-2). The last sampling point, at the drill rigg, exceeded the number of cultivable microorganisms before the UV-unit, indicating a contamination source within the drill water line. 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.

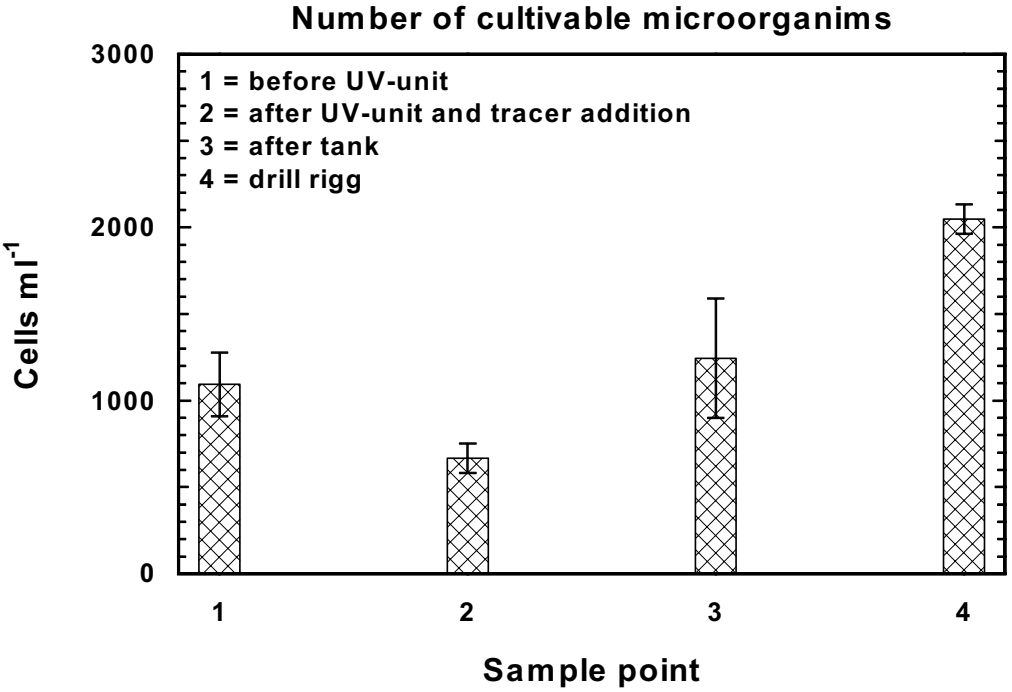


Figure 4-2. *The numbers of cultivable microorganisms. See Figure 3-1 for positions of the sampling points. Bars indicate standard deviation for two independent measurements.*

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. The length between the times T1 and T2 were: before UV 15 min, after UV 14 min, after tank 17 min, at drill rigg 17 min. This was done to assay the variability in time and sampling procedure. Figure 4-3 shows the results. There was a limited variability in most sampling occasions, indicating good reproducibility in the sampling and analysis procedures.

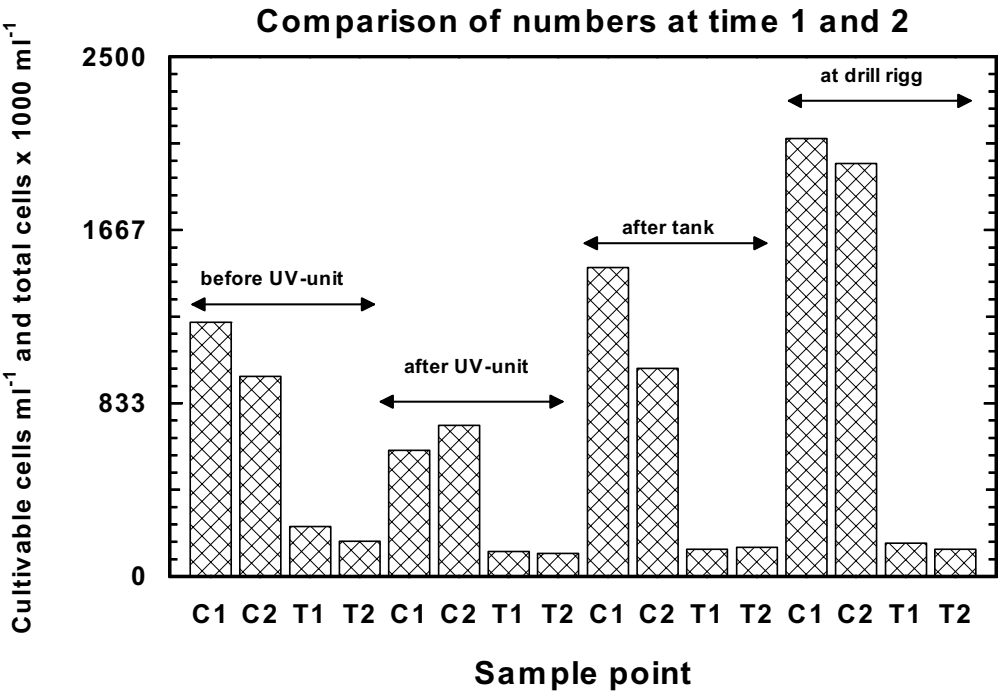


Figure 4-3. *Variability in data as distributed over sampling times 1 and 2. T represents total number and C represents cultivable numbers. 1 and 2 represent sampling time 1 and 2.*

5 Conclusions and suggested improvements

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 operating at their designated effect. Another possibility is that the tubings, tanks etc. downstream the UV-unit is dirty or not well rinsed and washed. 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.

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. The increase in cultivable microorganisms after the UV-unit (Figure 4-3) indicates sources of contamination downstream 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

Haveman S H, Pedersen K, Routsalainen P, 1999. Distribution and metabolic diversity of microorganisms in deep igneous rock aquifers of Finland. *Geomicrobiology Journal* 16, 277–294.

Pedersen K, Ekendahl S, 1990. Distribution and activity of bacteria in deep granitic groundwaters of southeastern Sweden. *Microbial Ecology* 20, 37–52.

Pedersen K, Hallbeck L, Arlinger J, Erlandson A-C, Jahromi N, 1997. Investigation of the potential for microbial contamination of deep granitic aquifers during drilling using 16S rRNA gene sequencing and culturing methods. *J Microbiol Methods* 30, 179–192.

Pedersen K, 2002. Site investigations in the Forsmark area. Control of microorganism content in flushing water used for drilling in KFM01A. *SKB P-03-03*, ISBN 1651-4416. Svensk Kärnbränslehantering AB.