COMBINED NANO-BIO TECHNOLOGY FOR REMEDIATION OF CONTAMINATION BY HEXAVALENT CHROMIUM:

OBSERVED EFFECTS OF IN-SITU NANO ZVI APPLICATION ON POPULATION OF INDIGENOUS MICROORGANISMS

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COMBINED NANO-BIO TECHNOLOGY FOR REMEDIATION OF CONTAMINATION BY HEXAVALENT CHROMIUM

**In Situ** Geo-fixation method

Cr$^{6+}$ – toxic, soluble, reactive
Present in aqueous form

→ Reduction

Cr$^{3+}$ less reactive and toxic,
Formation of insoluble compounds

COMBINED NANO-BIO REMEDIATION TECHNOLOGY

1$^{st}$ step – chemical reduction
utilization of nZVI

2$^{nd}$ step – bio-reduction
indigenous microorganisms
stimulation

Laboratory experiments carried out to optimize the technology

Pilot scale test performed on Cr$^{6+}$ contaminated locality
Background information

COMBINED NANO-BIO REMEDIATION TECHNOLOGY

- Indigenous microorganisms proved to be capable of bio-reduction after addition of organic substrate
- No adverse effects of nZVI application on indigenous microorganisms were observed during the laboratory experiments
- Risk of nZVI application on real Cr\(^{6+}\) contaminated site
- Monitoring of the locality before and after nZVI application
Background information

Locality Kortan

- old contamination by Cr$^{6+}$ originating from potassium dichromate
- nowadays Cr$^{6+}$ concentrations in ground water do not exceed 3 mg/l
- aquifer - shallow (9-10 m)
  - well permeable
- water table at a depth of 4-5 m

Monitoring and application system

- 7 different newly drilled boreholes
Background information

nZVI application in end of august 2012

- NANOFER 25 used (produced by NANO IRON, Ltd.)
  - reactive, stabilized solely by an inorganic modifier
  - higher toxic potential

- 120 kg of nZVI applied in form of suspension in 60 m³ of tap water
  - 2 g/l nZVI
  - based on previous laboratory tests
  - application by gravity
Materials and methods

- **In Situ measurement of pH and ORP**
- **Cr\(^{6+}\) concentration analysis**
- **Microbial Cultivation Tests**
  - Anaerobic, facultative anaerobic bacteria, sulphate reducing bacteria and psychrophilic bacteria.
- **Toxicological tests**
  - with *Vibrio Fischeri*.
- **Phospholipid fatty acid (PLFA) analysis**
  - determines specific fatty acids characteristic for different groups of microorganisms commonly found in the environment.
Results – pH

- Before application average pH 4.5 – 6
- In application boreholes significant increase, pH still high
- In monitoring boreholes decreased soon
Results – ORP

- Before application average ORP between +200 to +400 mV
- In application boreholes significant decrease, ORP still low
- In monitoring boreholes decreased, increased in time
Results – Cr$^{6+}$

- Before application Cr$^{6+}$ conc. varied between 0.8 – 2.5 mg/l
- In application boreholes decrease under the limit of quantification
- In monitoring boreholes decreased, increased in time
Results

Cultivation tests - Psychrophilic bacteria

- Before application average psychrof. bact. counts $1.2 \times 10^3$ CFU/ml
- After application average psychrof. bact. counts $1.3 \times 10^3$ CFU/ml
- No significant change observed after nZVI application
Results

Cultivation tests

- Sulphate reducing bacteria
  - not detected during the monitoring

- Anaerobic and facultative anaerobic bacteria
  - only few detected before and also after application
Aqueous samples analyzed
- filtered through microbial filters
- extracted for PLFA analyses

Several parameters analyzed:

* bacteria, anaerob, actinobacteria, G+, G-, total mikrob biomas, fungi
Results and Discussion

Effect of nZVI application on indigenous microorganisms

- No significant change in parameter bacteria after application
- Surprisingly high anaerob in borehole PV-214 after application – fault?
- No significant changes for both parameters in the rest of boreholes
Results

Ecotoxicological tests with *Vibrio fischeri*

- Low toxic effects of ground water against luminescence - only relative inhibition recorded
- Stimulation effects after application
- Cr$^{6+}$ concentration is not the only parameter affecting toxicity
Conclusions

Observed effects of in situ nZVI application

- Decrease of ORP and Cr\textsuperscript{6+} concentration, increase of pH
- No significant changes in amount of cultivated bacteria and concentrations of PLFA were observed
  - No adverse effects of nZVI application observed
  - The decrease of Cr\textsuperscript{6+} concentration did not enhance biomass growth
- Composition of microbial biomass seems not to be significantly affected
- Toxicological tests did not show increase of toxicity to \textit{Vibrio fischeri}
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Thank you for your attention.

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