The Effect of ISCO Agents on Soil and Groundwater Microorganisms

Jiri Mikes[1], Martina Siglova[1], Miroslav Minařík[1,2]
[1]*EPS, s.r.o., V Pastouškách 205, 686 04 Kunovice*
[2]*EPS biodegradácie, s.r.o. Hurbanova 65, 901 01 Malacky*
www.epssro.cz - jiri.mikes@epssro.cz - vyvoj@epssro.cz

The effects of in-situ chemical oxidant (ISCO) agents on indigenous microorganisms and microcosms augmented with allochthonous strains were studied in laboratory systems with environmental matrix material. Cell enumeration was used to measure the changes in cell density, and CO2 production (respirometry) was used to evaluate metabolic activity after exposure to ISCO agent. The cell enumerations showed that ISCO agent concentrations up harmfully affect both the indigenous microorganisms and were detrimental to allochthonous strains. The results emphasize the necessity of using reliable methods in order to realistically assess the potential effects of in situ chemical oxidation on soil microorganisms. A comparison to other studies suggests that the effect of ISCO agents on microorganims is very miscellaneous but generally always detrimental.

Introduction

Methods of in situ chemical oxidation (ISCO) are frequently used remediation tool designed to eliminate old environmental burdens and other environmental accidents. The presence of artificial (anthropogenic) chemical compounds in the rock mass is the main factor which influences the methodical option. Inconsiderable fact that must be paid appropriate is the attention to the impact of the presence of the ISCO reagent, to its (potential) intermediate products and pollutants and adverse effects resulting from the oxidation of the soil microflora. Effect of ISCO methods should be studied both in the engineering level of the own technological process, and particularly after, in terms of so called regeneration (restoration of biological equilibrium).

The impact of the ISCO on the native population of microorganisms presented in the locality (where it is considered to use methods based on the ISCO principles) is not well enough understood. Opinions on these effects are highly polarized, there are countless forms of supporters of non-biological degradation of presented organic load, on the other hand, you can trace a series of contradictory opinions that highlight the negative effects of industrial chemical reagents, aimed at autochthonous biota, thus collectively all living organisms. The truth most likely lies within this spectrum of these opinions. It is undisputed fact that any oxidizing agent adversely affects living organisms. The reason for this finding is based on the fact, that oxidation is incompatible with the character of the vast majority of biological macromolecules and polymers, which are elementary structural components of living organisms. In the case of events that take place in the area affected by the increased content of anthropogenic contaminants, the application of chemical oxidizing agents greatly influence the

bioremediation processes running on a platform of natural attenuation mechanisms. It should be respected, that it is not easy to objectively quantify the actual number and representation of all species, in particular microbial strains. Conventional culture methods describe the character of only 3100 of microbial genera and they are based on different evidence. Molecular tests and bio-evolutionary hypotheses are assumed that the total number of microorganisms, whose natural habitat is the Earth, oscillates in the range 300 000 - 1 000 000 microbial genera. At an average of 1 gram of soil sample was determined by molecular techniques approximately around 10 000 different microbial species [1], which is based on the previous set of facts stated that the available profiles of microbial communities far not correlate with the real situation. In the context of this paper referred to the particular consideration of the objectivity, the finding on how much can be leaned against misleading claims associated with the occurrence of so-called indicator organisms CFU (colony forming units). Estimation of the attenuation processes, bioremediation activity and ability to contribute to the form of biological degradation of contaminants is therefore even more uncertain.
The main purpose of this paper is to introduce new facts and to summarize the current state of knowledge on the impact of various ISCO agents, which found application in clean-up engineering practice, to the viability of microorganisms. Specifically, it focuses mainly on the potassium permanganate, Fenton's reagent and peroxodisulfate anions.

Impact on microbial population

In recent years, it has been possible to record two schools of thought. The defence presented a distinct method of ISCO as a universal remediation method of the contaminated parts of the environment. The other, which resonated particularly from the mouth of microbiologists, found that application of reagents ISCO leaving the site devoid of living forms, leads to the extinction of indigenous microbial communities and basically sterilized instead of surgery. At this point, it is desirable to state the circumstances under which the facts supporting the above claims has been obtained. In the case of pilot experiments on contaminated sites was clearly chucking all the attention on achieving the desired remediation limit the impact on the microbial community was monitored only marginally, if at all. The claim microbiologists in most cases defended the facts that emerged from the simulations and model structure based on the laboratory. Where are hiding the truth? Objective reality can be achieved if the data are interpreted in a transparent and be perceived in the context of the actual state of affairs. Indisputable assertions are two basic findings: 1) reagent-based ISCO are definitely for microorganisms such substances, which lead to their inhibition and death, 2) the natural environment is an open system with circulating hydrogeological mechanisms. Commenting on the first statement must be a finding that at the time of intervention tools based on methods of ISCO will be the death of microbial populations, which have already been exposed to the effects of selective pressure, pollutant, as a result of the interest in self-preservation could create a metabolic-physiological mechanisms that they allowed in the area to survive, grow and reproduce. The second claim certainly advocates argue that even after treatment at the site of chemical oxidation methods can occur naturally and repopulate. However, at this point must be clearly pointed out that due to the application of chemical oxidizing agents can cause a number of changes that affliction is having difficulty living

microorganisms identifiable. These include the accumulation of reduced forms ISCO agents the morphological structure of the geological environment and ultimately to mobilize some pure compounds, which also prevent microbial physiological activities of individuals (eg, local release of toxic metals deposits formed). A study that examined the impact of the activated peroxodisulfátu natural microbial population and the population that the sample came in the form of geological environment bioaugmentace, resulted in the finding that much more vulnerable to the effects of oxidation agent is the population of allochthonous (originating) comprising representatives from the original microbial community. [2, 3]

These findings should be viewed from two perspectives. Firstly, there is confirmation that the population exposed of long-term environmental effect is more resistant than strains cultured in artificial conditions with guaranteed availability of nutrients. On the other hand, does not contribute bioremediačním present population of pollutant degradation. The fact that the surgery will be treated to the recovery site bringing microbial specimens due to the openness of the geological environment, it can be seen as a natural form of bioaugmentace (but with the risk that the tribes will go through the longer process of adaptation) does not find convincing but with regard to possible post- Remediation further treatment. The key criterion is impact on the integrity of its own oxidation of cellular structures of micro-organisms that were exposed to an oxidizing agent. Here it should be noted that the presence of oxidative agents in the environment is incompatible with life present microflora. Experiments performed with commonly used oxidizers (permanganate, Fenton's reagent and persulphates) at rates specified in the methodological materials are definitely microbicidal effect. In all three cases led to their application to total microbial population of the study sample (geological environment contaminated by oil). Physiological activity was monitored by respirometrical determination of carbon dioxide.

Reinokulací thus treated samples of the rock environment, it was found that the introduction of dominant taxa isolated from the original environment, it does not prevent their ability to repopulate the modified environment, but in terms of monitoring tests respirometrickými dropped these indicators of physiological activity compared with those before treatment, chemical oxidizing agents. Noticeable decline when adjusted for a comparable amount of microbial counts of individuals (in CFU) was observed when permanganate applications. Respiratory activity decreased to 25% of original value. In the case of treatment Fejtonovým agent, the value of reduced respiratory activity and was 65% when applied persulphates respiratory activity decreased to a value of 70%. From these results it is possible to conclude that the main reason for the decline of respiratory activity of microbial population is not ready for the new conditions which are mainly determined by the presence of reduced forms of oxidative agents. Against the indigenous population introduced into the treated matrix rock environment is the most negative impact of the presence of reduced forms of permanganate (pyrolusite). Reduced forms of the products exiting the application of Fenton reagent and peroxodisulphate have significantly less effect than mikrobistatický said manganese oxides.

Summary

The main purpose of this paper is primarily to point out continuity of the original micrioflora and application of remediation methods based on ISCO in the context of the pollutant into harmless breakdown products (bioremediation, natural attenuation). There is no need to condemn the method as a tool ISCO decontamination technologies with significant negative side effects, however, need to be aware of them and, in particular, in constructing their own remedial surgery to treat these issues comprehensively, with an emphasis on finding such appropriate conditions and parameters that will combine different approaches with regard to the fate of the treated area.

References

[1] Colwell, RR, Grimes, DJ (2000): Nonculturable Microorganisms in the Environment. ASM Press.
[2] TSITONAKI, A., SMETS, B.F., BJERG, P.L. (2008): Effects of Heat-activated Persulfáte Oxidation on Soil Microorganisms, Water Research 42, 1013-1022.
[3] BLOCK, P. (2009): The Effect of Activated Klozur Persulfáte ISCO on Microbial Population, Peroxygen Talk (available on the website of the FMC).