

of the soil, thus affecting the thermal regime and microbial activity, and so the age and amount of contamination was important. Unfortunately multiple spills occurred in the Usinsk region and their age was not recorded. Answering final questions Lothar explained that although in addition to control of the hydrocarbon content assessments of the biological state of the soil were needed, they were too expensive at the moment to use for the large contaminated areas in question.

The second presenter was Oleg Anisimov, who focussed attention of the participants on the implications of climate change for the permafrost regime and bioremediation. He emphasized that, firstly, wide-scale remediation was on the agenda (350,000 km of pipelines in Russia are associated with tens of thousands of hydrocarbon spills). Secondly, the *transport* of oil within the ground water and soil horizons had to be considered. Global warming might cause deepening of the active layer. Different regions where spills occur should be ranked according to their risk potential. Thirdly, the geographical classification and ranking of assessment methods was needed. Bernard Stonehouse asked whether global warming and advance of the tree line to the north would necessarily mean more ground water available and massive pollution of rivers and streams. Oleg Anisimov reasoned that this is generally unlikely, because the deepening active layer will reduce the surface runoff. Therefore, if the active layer lies above the level of ground water the negative effects would be small. However, if the ground water level were to be higher than the active layer, the contamination would be dramatic. Answering the further question on the time range of the future climate change, Oleg Anisimov expressed the opinion that it would be most likely centuries, but, as is known, the most significant changes are expected in the Arctic (possibly up to 2°C over 50 years). This may influence prospects for bioremediation.

Anatoly Brouchkov spoke on the energy of spores and bacteria and their capacity for long life (in the frozen state). This was supplemented by the remarks of Ivan Gogotov on the wide temperature range in which certain bacteria exist, depending on pH, temperature, water and dielectric potential. This gives the possibility of continuous cultivation of microorganisms for bioremediation and restoration of ecological systems.

Xavier Chatellier raised the question of the organisation of bacteria and biofilms, and asked how this was modified in the frozen ground. Anatoly Brouchkov responded with the following set of research questions: i) what are the ways of heating the frozen ground? ii) what are the rates of contamination in permafrost and how are they connected with unfrozen water? iii) what are the relationships between microbes, soil, ice, and unfrozen water? Anatoly emphasised that the vast scales of contamination in Russia suggested natural attenuation as the main bioremediation method. Xavier noted that hydrophobicity of soils can be changed by adding certain components and Anatoly briefly overviewed the Arctic saline ground (cryopegs) with lower freezing temperatures and the associated environmental problems (including unsuitability for storage of radioactive waste).

In the final part of the discussion Bernard Stonehouse emphasised that extensive treatment of soils *in situ* using artificial heating may be expensive, and lead to further destruction of soil. He asked what would be the effect of global warming as a natural regulator. Oleg Anisimov agreed with Bernard's points saying that areas of current infrastructure on permafrost should not be heated, and noted that with global warming the probability of oil spills will increase and called for assessment of off-site remediation potential. The question was raised to which extent the remediation should go. Oleg Anisimov reinforced the earlier points about the natural attenuation approach in Siberia as the only feasible, in view of the large scale of the problem. Anatoly Brouchkov stressed that preventing further oil pollution in Siberia was not only a financial, but also a moral matter for all sides involved. Xavier Chatellier concluded by wishing that much larger funding were available for remediation in Siberia.

Fundamental studies relating to contaminant remediation

Chairman: Jaime Aguirre-Puente

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This workshop considered the role of basic or fundamental research studies in relation to the Conference theme of contamination. By fundamental studies is usually meant research devised for the sake of 'finding out', of increasing knowledge in an area, but not directly motivated by immediate practical need.

The great differences between miscible and immiscible substances (those that dissolve in soil water and those that do not) and the significance this has in freezing and thawing soils was examined.

The group considered the need for those who are responsible for contaminant clean-up, for background knowledge. Such background knowledge is the information that has derived from the research categorised as fundamental, and, without which, it is not possible to develop new techniques.