August 2010

Review of Observatory NANO Focus Report 2010
"Nano zero valent iron - THE solution for water and soil remediation?"

In May 2010, the reputable European Nanotechnology Gateway organisation published a lengthy report entitled "Nano zero valent iron - THE solution for water and soil remediation?" A copy is available via their website at http://www.observatory-nano.eu. As European technology vendors, we asked colleagues at our Canadian affiliate; EnviroMetal Technologies Inc (ETI) to review this report. It presents information on nanoscale zero valent iron (nZVI) use in the EU. As many readers will know, ETI is the originator of ZVI permeable reactive barrier (PRB) technology, and has over 20 years of global experience in field-scale ZVI applications.

The "NANO Focus Report-2010" report contains useful data concerning nZVI suppliers and case studies in the EU. The numerous challenges surrounding this technology described in the report's conclusions reinforce our opinion that while high reactivity nanoscale metals represent an intriguing development in contaminant remediation, significant questions concerning their technical performance and cost, as well as related health and safety issues, need to be answered before these particles can be considered for widespread use as a commercial remedial option.

Other specific comments include:

- Perhaps one drawback of the "NANO Focus Report-2010" is that certain nZVI vendors seem to have been relied upon for information on delivery and cost comparisons to other technologies; based on our experiences we believe several of these cost estimates would not be validated by third-party evaluations.

- The "NANO Focus Report-2010" compares nZVI with iron PRB technology. Oft-repeated, erroneous attributes of PRBs are listed therein (*i.e.*, uncertainty regarding lifetime, depth limitations). A more appropriate comparison would be to contrast nZVI with other injectable amendments, including Adventus' EHC® technology, microscale ZVI, and even our competitors' aqueous carbon-only amendments.

- The effectiveness (reactivity) of nZVI versus granular iron is discussed in the "NANO Focus Report-2010", but its cost-effectiveness is not given a rigorous review. Micro-scale ZVI (or other injectable amendments) may be much more cost-effective than nZVI, depending on the VOC concentrations requiring treatment, especially since nZVI will not persist long in the sub-surface environment, relative to these other materials. Liles (2009) contains an excellent discussion of nZVI reactivity issues. It should be noted that many nZVI laboratory–scale reactivity studies do not test field-stabilized nZVI, and these organic-based stabilizers have been shown to have an adverse effect on nZVI reactivity.

- Nurmi *et al* (2005) state that surface-area normalized reaction rates of common nZVI are similar to that of micro-scale ZVI. In many instances, microscale iron can be obtained for roughly 1/20th the cost of nZVI (*e.g.,* Quinn *et al* 2009), and it is our understanding that many recent applications of NASA's emulsified zero valent iron (EZVI) have used micro-scale ZVI, rather then nZVI, for this reason.

- A cost range of about \$120-300 Euro/m^3 (roughly US \$150 to \$400/m^3) is reported for nZVI applications. By comparison, ZVI-clay technology for DNAPLs can be applied at costs of about US \$90 to \$200/m^3 (US \$70 to \$150/yd^3; Olsen and Sale, 2009), and recent EHC® applications in high concentration source areas have cost about US \$35 to \$70/m^3(Peale *et al*., 2010)

- The radii of influence for nZVI injections mentioned in the report are somewhat confusing. Tratnyek and Johnson (2006) present theoretical considerations indicating that transport in most aquifer environments will be limited to a few meters, which is certainly the case in most field applications that we are aware of. It is interesting that some 10 years after nZVI technology was introduced, fundamental studies are still being funded in attempt to accurately gauge the mobility of these materials (SERDP, 2010).

- The possible biological toxicity, potential human health effects, and recognized material safety hazards related to the use and application of nano-scale materials in a soil, sediment or water environment merit a second publication on their own, rather than the somewhat limited discussion presented in the "NANO Focus Report-2010". For example, both German and US agencies (Orthen, 2007; US National Science and Technology Council, 2006) have published comprehensive strategies for evaluating potential human and ecological health issues related to nanoscale materials.

In addition to the references given above, the readers are directed to the following sources of information concerning nZVI technology:

- US EPA Nanotechnology for Site Remediation Fact Sheet (**http://www.epa.gov/tio/download/remed/542-f-08-009.pdf**)

- A detailed review of a California Groundwater Resource Association meeting held in the fall of 2009 on nanotechnology in the environment (**http://www.grac.org/spring10.pdf**)

- The environmental sciences and engineering center at the Oregon Graduate Institute maintains a searchable database containing several articles pertaining to nZVI (**http://cgr.ese.ogi.edu/cgi-bin/**)

On a related note, the US Interstate Technology Regulatory Council (ITRC, in preparation) will be publishing an updated PRB guidance document in the Fall of 2010, which will include a thorough discussion of PRBs for VOCs and inorganics. We will present a review of this document in an upcoming Adventus newsletter. ***For more information concerning this article or related information on ZVI, please contact John Vogan at john.vogan@adventusgroup.com***

References and additional information on the web:

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US National Science and Technology Council, Nanoscale Science Engineering and Technology Subcommittee, Committee on Technology, 2006. Environmental, Health, and safety research needs for engineered nanoscale materials. September 2006. Accessed at http://www.whitehouse.gov/files/documents/ostp/NSTC%20Reports/NNI_EHS_research_needs%202006.pdf