A green future for scrap iron

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Take a close look at that cheap piece of scrap iron before you toss it in the trash. Wei-xian Zhang has a good use for it. Someday soon, much of the world might also.

Zhang, a professor of civil and environmental engineering, recently concluded a five-year research project in which he and his colleagues at Tongji University in Shanghai used two million pounds of iron to detoxify pollutants in industrial wastewater.

The project, carried out in Shanghai, was the largest in history to use iron in an environmental application. The iron, called zero valent iron (ZVI) because it is not oxidized, was obtained in the form of shavings or turnings from local metal-processing shops for less than 15 cents a pound.

An article written by Zhang and Luming Ma, professor of environmental engineering at Tongji University in Shanghai, was published recently as the cover article by *Environmental Science and Technology*. The article was titled ""Enhanced Biological Treatment of Industrial Wastewater with Bimetallic Zero-Valent Iron." *ES&T*, a bimonthly published by the American Chemical Society, is the leading journal of its kind.

The ZVI project began with small, "benchtop" experiments in the laboratory that used a total of 90 pounds of iron to treat toxins in solution. It graduated in 2005-06 to a pilot test using 2,000 pounds of iron to pretreat wastewater at a treatment plant in the Taopu Industrial District in Shanghai. Wastewater at the Taopu plant, which is generated

by small chemical, materials and pharmaceutical companies, had previously been treated with microorganisms alone. ZVI augmented and improved this remediation method.

Following the pilot test, the Shanghai city government approved a grant to construct a full-scale treatment reactor in the Taopu district capable of processing almost 16 million gallons a day of wastewater. This ZVI reactor was connected to the biological treatment plant two years ago and has been in continuous use since. The system was recently certified by Shanghai's Municipal Environmental Protection Bureau.

The addition of ZVI to the traditional biological methods of wastewater treatment resulted in a significant improvement in pollutant levels, according to Ma, who directs the National Engineering Research Center for Urban Pollution Control in Tongji's College of Environmental Science and Engineering. The removal of biological oxygen demand (BOD) rose from 76 to 87 percent. Improvements were also recorded with the removals of nitrogen (13 to 85 percent), phosphorus (44 to 64 percent), and colors and dyes (52 to 80 percent).

"Before this project," says Ma, "few people believed scrap iron could work in a wastewater treatment plant. We have developed a copper-activated iron and used a systematic approach – from benchtop to pilot to full-scale tests – to show that ZVI-enhanced treatment can achieve dramatic improvements over biological processes used by themselves."

While biological methods, including biofilms and aerobic organisms, are effective at treating municipal wastewater, Zhang and Ma wrote in the *ES&T* article, they enjoy limited success in treating the less biodegradable and often toxic compounds in industrial wastewater, many of which are synthetic organic chemicals.

These chemicals are attracted to the surface of the iron, where they share

electrons with the iron and are degraded and detoxified. The ZVI, which undergoes oxidation during this exchange, has a useful lifetime of about two years in the treatment process.

The ZVI scrap iron is chemically similar to iron-based nanoparticles invented by Zhang that are now widely used in North America to clean decontaminated soil and groundwater. The nanoparticles contain 99.9 percent iron and about .1 percent palladium or other Noble elements.

Zhang says the scrap iron's low cost gives it great potential to be used in developing countries where nanoparticles' cost – about $50 a pound – can be prohibitive. In China, Zhang and Ma note in their article, the textile industry alone generates two billion tons of wastewater each year.

Source: Lehigh University