

Agricultural Practices by Enhanced Water Quality through Iron-Based (Ferrate) Technology: Improved Population Health

Virender K. Sharma

Program for the Environment and Sustainability
Department of Environmental and Occupational Health,
School of Public Health, Texas A&M University,
College Station, Texas 77843, USA.
vsharma@tamu.edu

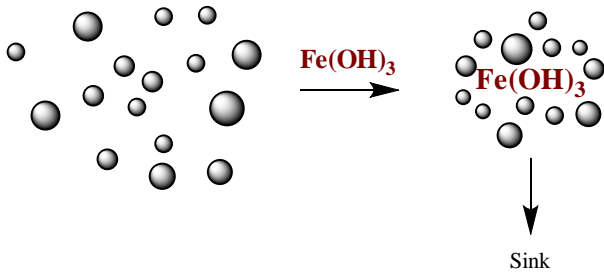
Ferrate^{VI} – Multimodal Actions

Potential Applications of Ferrate Technology in
Food, Energy, Water and Population Health

Oxidation

Antibiotics Removal

Decrease Disinfection
Byproducts

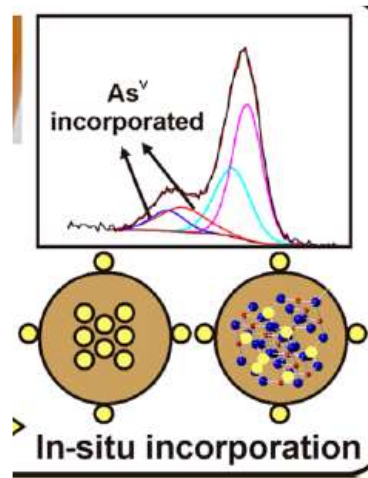


Ferrate^{VI}

Coagulation
Adsorption
Fe(III)

Disinfection

Arsenic
Removal



Bacteria
Virus

Iron Oxide Compounds at Different Oxidation States of Iron

Compound	Name	Mineral/Salt	
Fe	Iron Rod		d ⁸
FeO	Ferrous oxide, Fe ^{II}	Wüstite	d ⁶
Fe ₂ O ₃	Ferric oxide, Fe ^{III} (<i>Resting</i>)	Hematite	d ⁵
FeO ₄ ⁴⁻	Ferrate ^{IV}	Medium Active	Na ₄ FeO ₄ d ⁴
FeO ₄ ³⁻	Ferrate ^V	Highest Active	K ₃ FeO ₄ d ³
FeO ₄ ²⁻	Ferrate ^{VI}	Active	K ₂ FeO ₄ d ²

Liquid Ferrate Formulation Surface Disinfectant

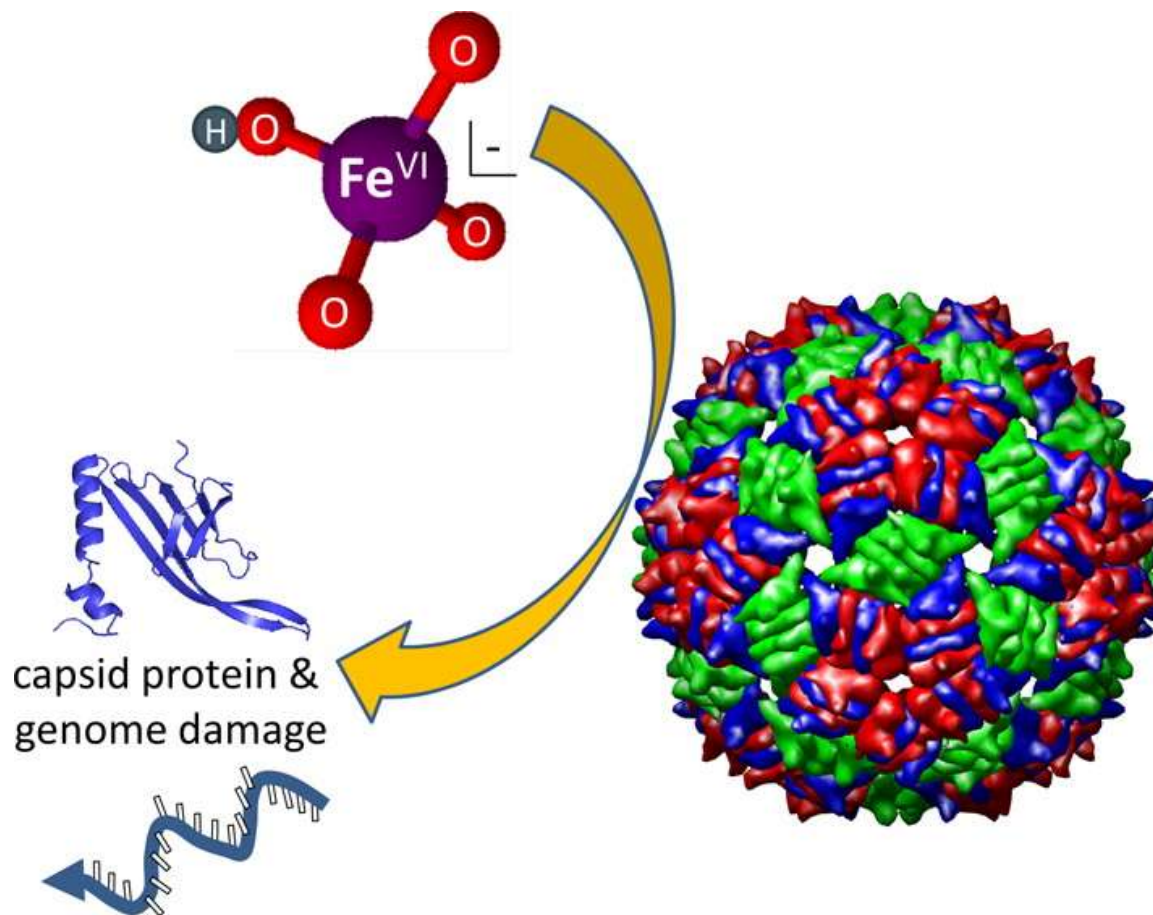
- Methicillin-resistant *Staphylococcus aureus* (MRSA)
- *E. coli*
- *Clostridium difficile* spores

6-log reduction (EPA Protocols)

Innovation - Two minutes

Ferrate^{VI}

Inactivation of Bacteriophage MS2

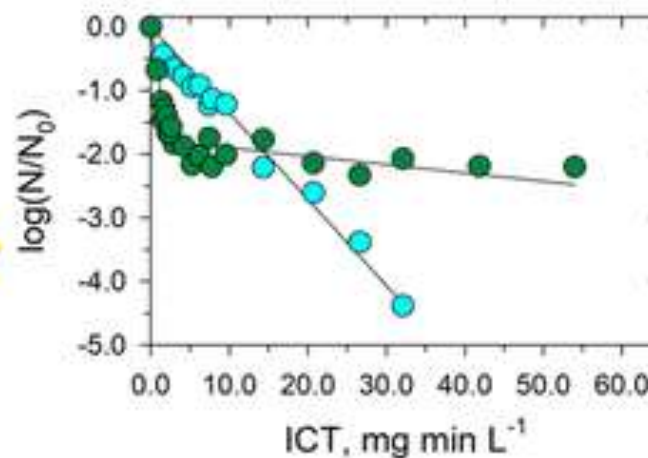
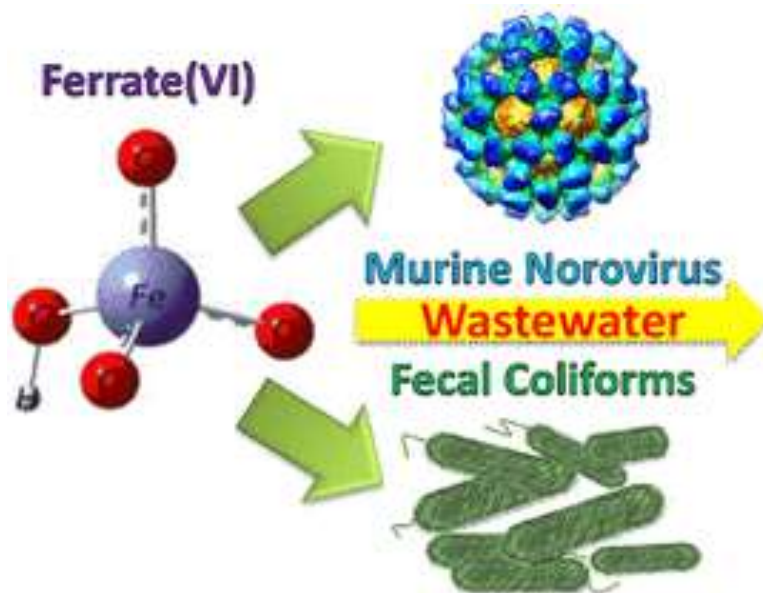


Norovirus at Yosemite

170 visitors and employees suffering symptoms



Park officials had confirmed two cases of norovirus, but dozens of Yosemite Park visitors and employees reported gastrointestinal illness



Contaminants of Emerging Concerns - *Pharmaceuticals and metabolites*

- Annually ~\$330 billion spent on medication in the U.S.
- A large portion of the prescribed pharmaceuticals are excreted unchanged or as metabolites in urine and feces.
- May pose adverse toxicological effects on the ecosystem and human health



Human urine contributes **>60%** of pharmaceuticals to the wastewater

Source Separation of Urine

Recovering nutrients, particularly nitrogen and phosphorus, in source-separated urine to produce fertilizers

Problem – Antibiotics in Water

World Health Organization - 2019

- New report calls for urgent action to avert

antimicrobial resistance crisis

If no action is taken - warns the [UN Ad hoc Interagency Coordinating Group on Antimicrobial Resistance](#) who released the report – drug-resistant diseases could cause *10 million deaths each year by 2050* and damage to the economy as catastrophic as the 2008-2009 global financial crisis.

By 2030, antimicrobial resistance could force up to 24 million people into extreme poverty

Currently, at least 700,000 people die each year due to drug-resistant diseases, including 230,000 people who die from multidrug-resistant tuberculosis.

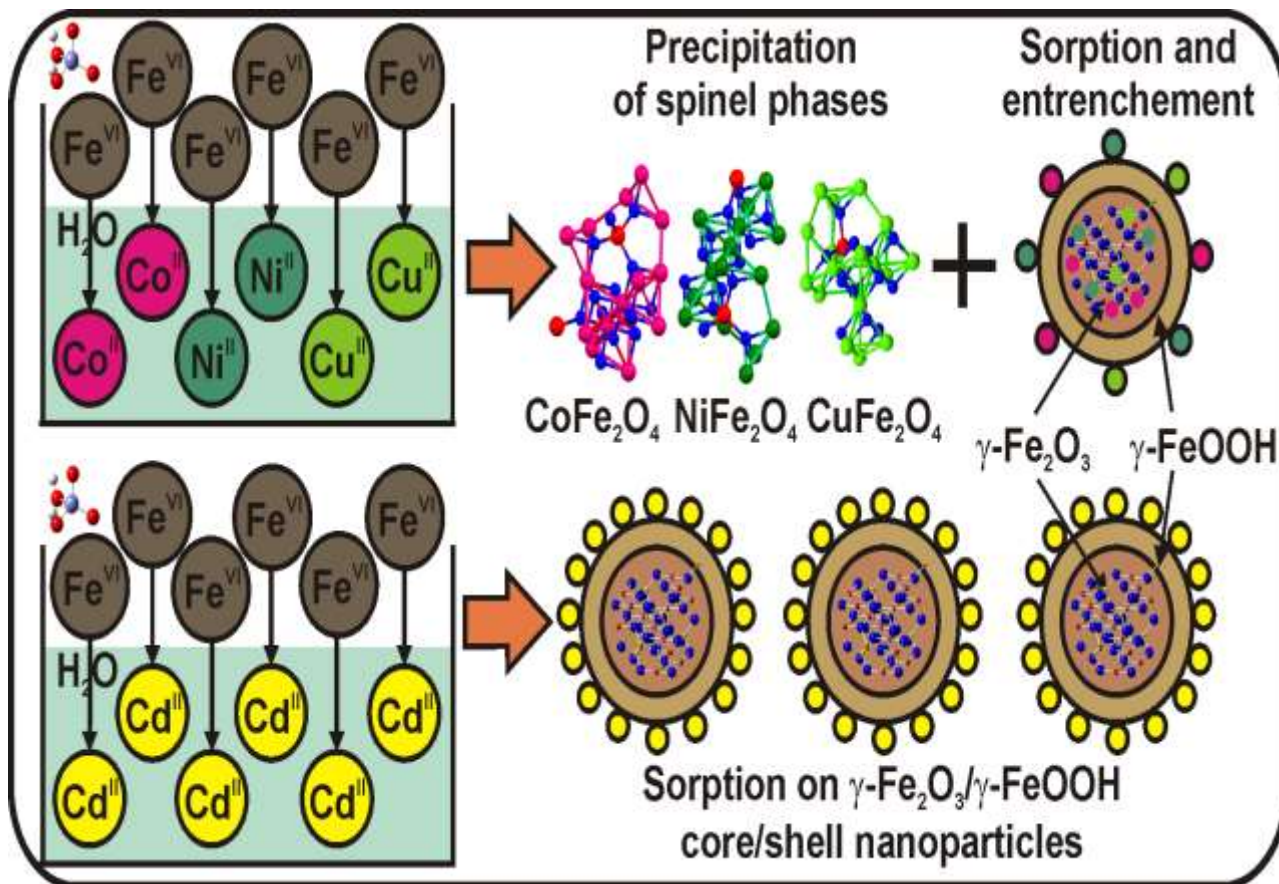
Ferrate^{VI} - Efficient Removal (in seconds) of Antibiotics in Water

Antibiotics

Sulfisoxazole	9 seconds
Sulfamethazine	13 seconds
Sulfamethizole	34 seconds
Sulfadimethoxine seconds	175
Sulfamethoxazole	10 seconds
Tetracycline	46 seconds
Trimethoprim	350 s

One of the Biggest Global Health Crisis of the Century

Ferrate(VI) Promoted Removal of Metals



Acknowledgements

U.S. National Science Foundation (CBET 1802800)

Dr. Chetan Jinadatha, VA Hospital, Temple, TX

Prof. Ching-Hua Huang and Cong Liu, Georgia Tech

Dr. Rajender S. Varma, USEPA

Prof. Ajay Ray, Western University, London, Ontario, Canada

Colleagues in Ferrate Research at TAMU