

A Critical Review of the Reactivity of Manganese Oxides with Organic Contaminants

Christina K. Remucal^{1} and Matthew Ginder-Vogel¹*

¹Department of Civil and Environmental Engineering

University of Wisconsin – Madison

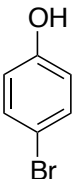
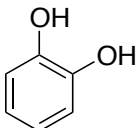
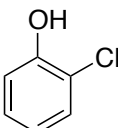
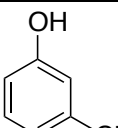
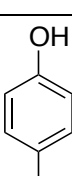
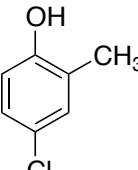
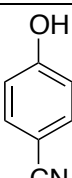
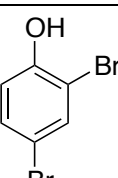
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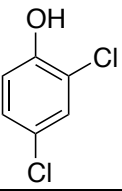
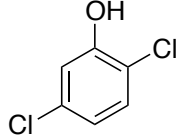
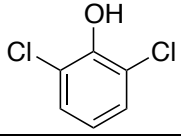
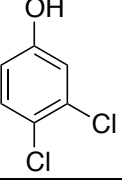
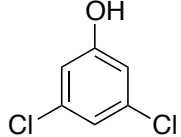
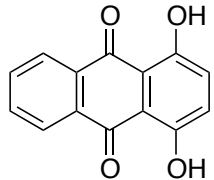
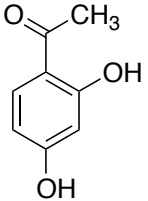
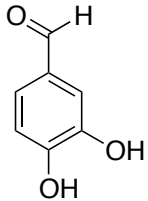
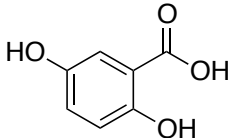
Submitted to: *Environmental Science: Processes & Impacts*, December 19, 2013

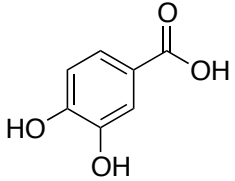
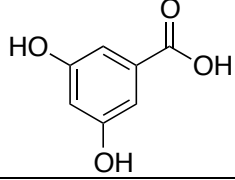
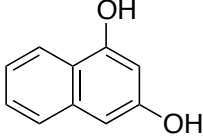
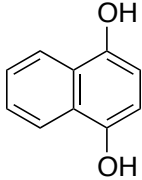
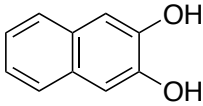
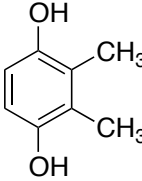
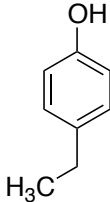
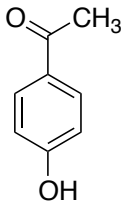
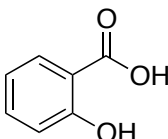
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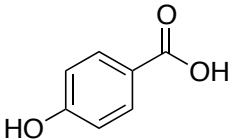
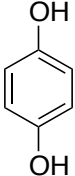
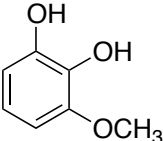
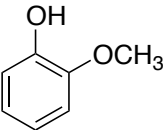
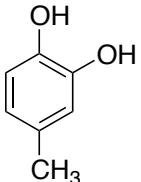
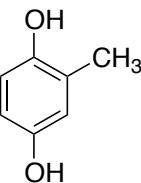
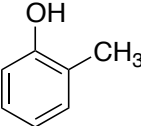
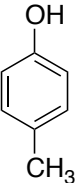
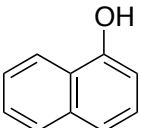
* Corresponding author e-mail: remucal@wisc.edu; telephone: 608-262-1820; fax: 608-262-0454.

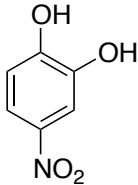
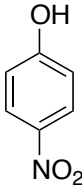
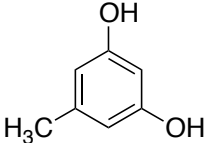
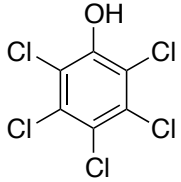
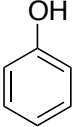
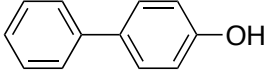
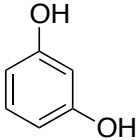
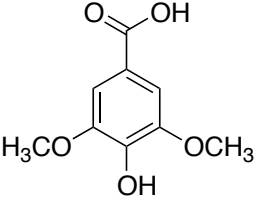
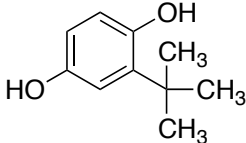
Table SI. Summary of model phenols and anilines used to reductively dissolve manganese oxides.

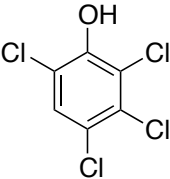
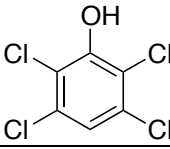
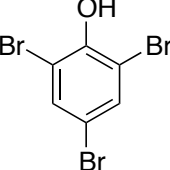
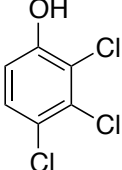
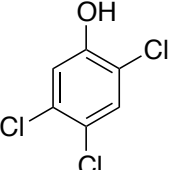
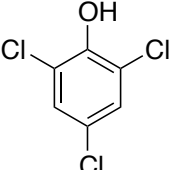
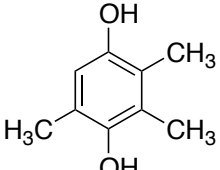
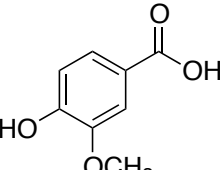
Compound	Structure	References
<i>Phenols</i>		
4-Bromophenol		1
Catechol		2-11
2-Chlorophenol		12-14
3-Chlorophenol		12, 13, 15
4-Chlorophenol		12-17
4-Chloro-2-methylphenol		14
4-Cyanophenol		16
2,4-Dibromophenol		1

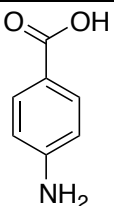
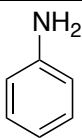
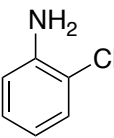
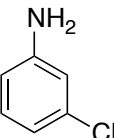
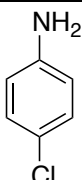
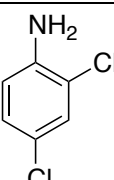
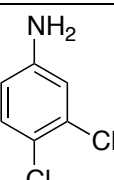
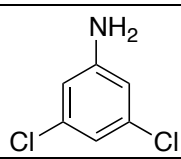
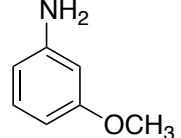
2,4-Dichlorophenol		13, 14, 16, 18
2,5-Dichlorophenol		12
2,6-Dichlorophenol		14
3,4-Dichlorophenol		13
3,5-Dichlorophenol		13
1,4-Dihydroxyanthraquinone		19
2,4-Dihydroxyacetophenone		16
3,4-Dihydroxybenzaldehyde		16
2,5-Dihydroxybenzoic acid		4

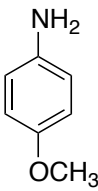
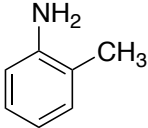
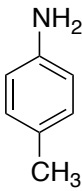
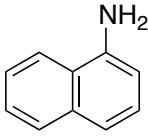
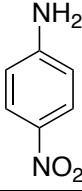
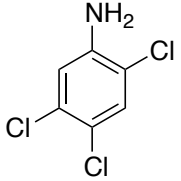
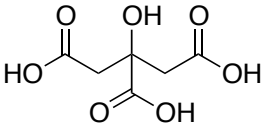
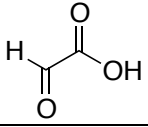
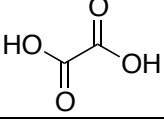
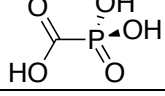
3,4-Dihydroxybenzoic acid		4
3,5-Dihydroxybenzoic acid		4
1,3-Dihydroxynaphthalene		19
1,4-Dihydroxynaphthalene		19
2,3-Dihydroxynaphthalene		19
2,3-Dimethylhydroquinone		8
4-Ethylphenol		15
4'-Hydroxyacetophenone		15
2-Hydroxybenzoic acid		15, 16

4-Hydroxybenzoic acid		15
Hydroquinone		3-8, 20-29
3-Methoxycatechol		4
2-Methoxyphenol		4
4-Methylcatechol		8
Methylhydroquinone		8
2-Methylphenol		17
4-Methylphenol		15, 16
Naphthol		30

4-Nitrocatechol		4
4-Nitrophenol		15, 16
Orcinol		4
Pentachlorophenol		13, 31, 32
Phenol		13-15, 17, 29, 33
4-Phenylphenol		16
Resorcinol		3, 4
Syringic acid		4
<i>tert</i> -Butylhydroquinone		8

2,3,4,6-Tetrachlorophenol		34
2,3,5,6-Tetrachlorophenol		13
2,4,6-Tribromophenol		1
2,3,4-Trichlorophenol		34
2,4,5-Trichlorophenol		12, 18, 34
2,4,6-Trichlorophenol		13, 14, 18, 34, 35
Trimethylhydroquinone		8
Vanillic acid		4

<i>Anilines</i>		
4-Aminobenzoic acid		8, 36
Aniline		8, 36-38
2-Chloroaniline		12
3-Chloroaniline		12, 39
4-Chloroaniline		8, 12, 36, 39-41
2,4-Dichloroaniline		12
3,4-Dichloroaniline		41
3,5-Dichloroaniline		41
3-Methoxyaniline		39

4-Methoxyaniline		8, 36, 37
2-methylaniline		39
4-Methylaniline		8, 36
1-Naphthylamine		8, 37
4-Nitroaniline		8, 36, 39
2,4,5-Trichloroaniline		12
<i>Low Molecular Weight Acids</i>		
Citric acid		28, 42
Glyoxylic acid		43
Oxalic acid		28, 44, 45
Phosphonoformic acid		43

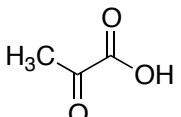
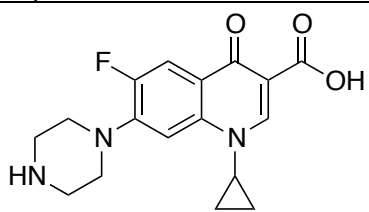
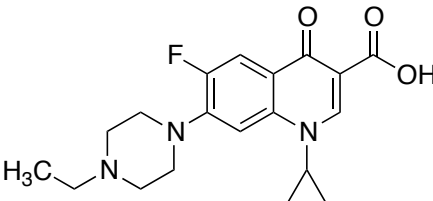
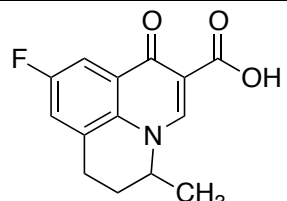
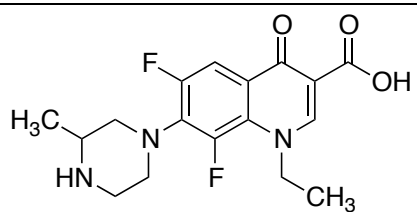
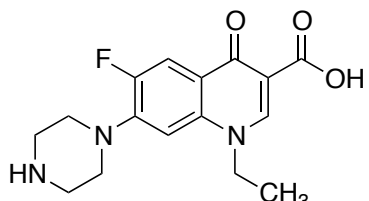
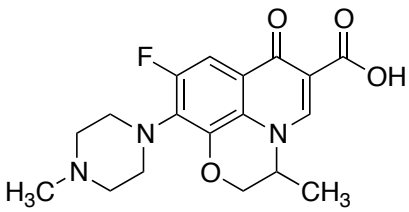
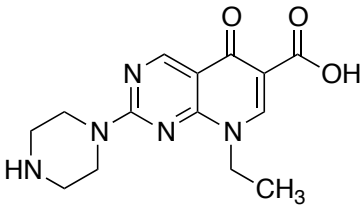
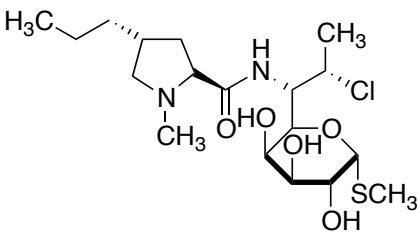
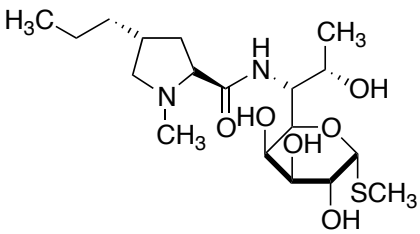
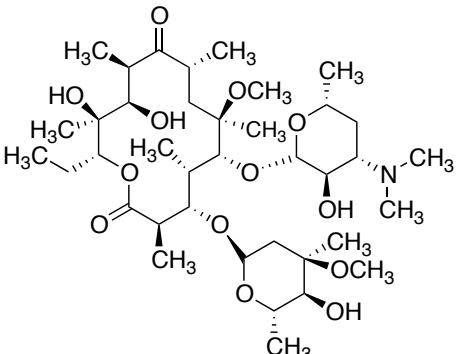
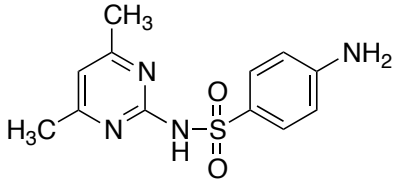
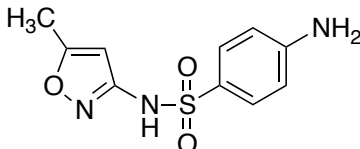
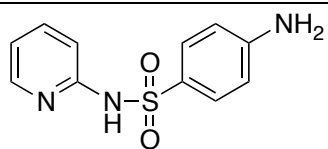
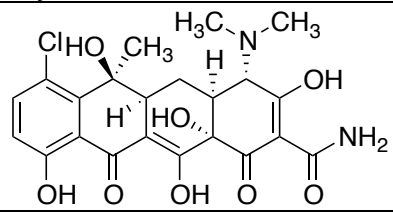
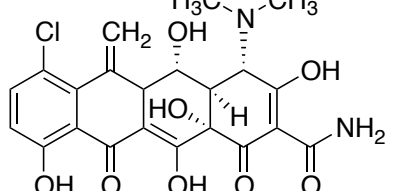
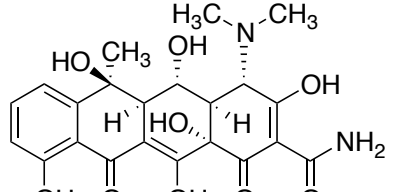
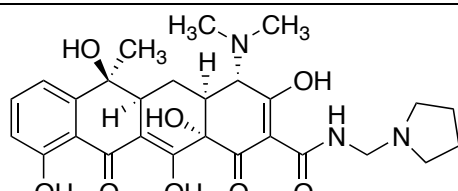
Pyruvic acid		28, 43, 44
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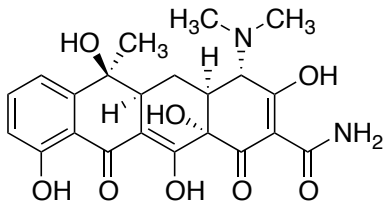
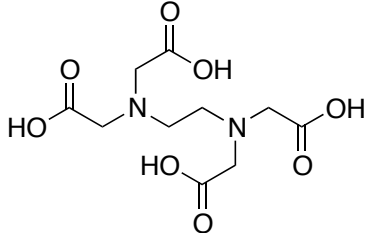
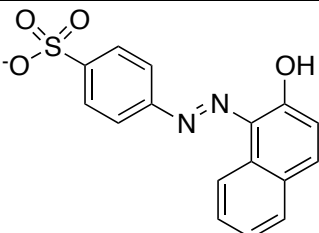
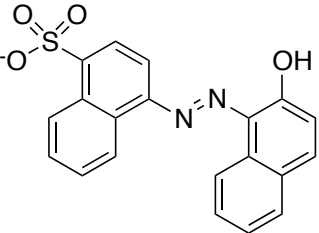
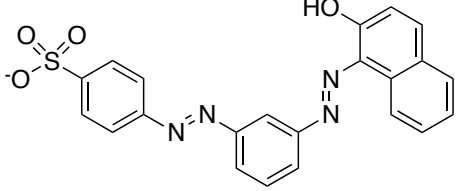
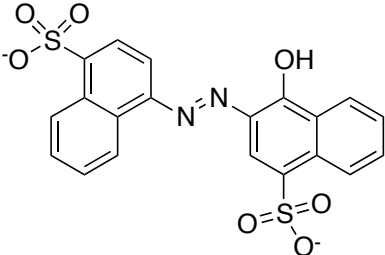
Table S2. Summary of organic contaminants known to react with manganese oxides.

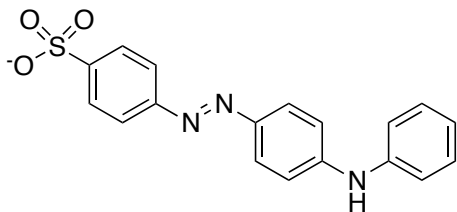
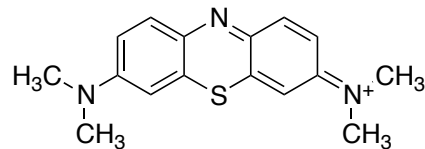
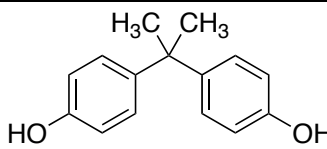
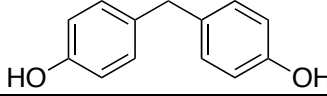
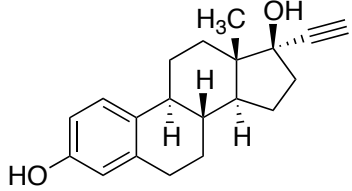
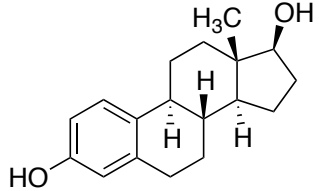
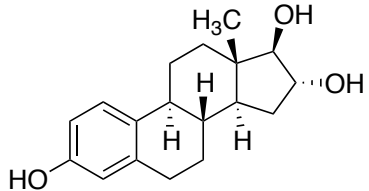
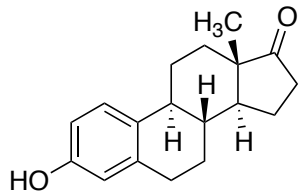
Compound	Structure	Contaminant degradation	Product identification
<i>Antibacterial Agents - Fluoroquinolones</i>			
Ciprofloxacin		46-49	46, 48
Enrofloxacin		46, 47	46
Flumequine		46	
Lomefloxacin		46, 47	46
Norfloxacin		46, 47	46

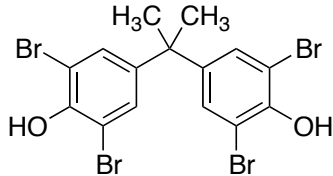
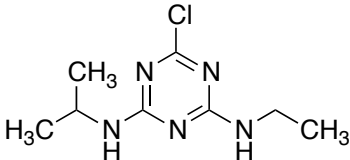
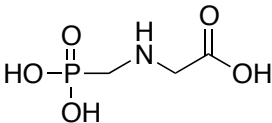
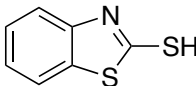
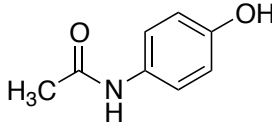
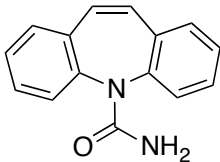
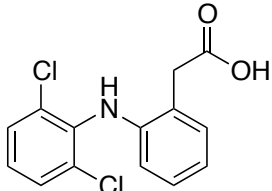
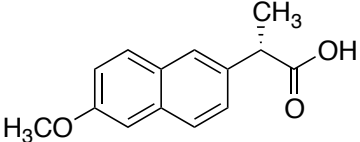
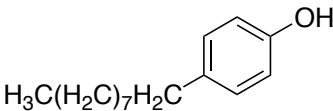
Ofloxacin		46, 47	46
Pipemidic acid		46, 47	46
<i>Antibacterial Agents - Lincosamides</i>			
Clindamycin		50	50
Lincomycin		50	50
<i>Antibacterial Agents - Macrolides</i>			
Clarithromycin		51, 52	

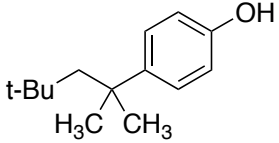
Roxithromycin		51	
<i>Antibacterial Agents – N-oxides</i>			
Carbadox		47, 53	53
Desoxycarbadox		53	
Olaquinox		53	
<i>Antibacterial Agents – Phenols</i>			
Chlorophene		47, 52, 54, 55	54
Triclosan		47, 52, 54, 55	54
<i>Antibacterial Agents - Sulfonamides</i>			
Sulfadiazine		56, 57	56, 57

Sulfamethazine		58, 59	59
Sulfamethoxazole		52, 58	
Sulfapyridine		58	
Antibacterial Agents - Tetracyclines			
Chlortetracycline		47, 60-62	61, 62
Meclocycline		60	
Oxytetracycline		47, 60, 61	60, 61
Rolitetracycline		60	

Tetracycline		47, 60, 61	61
<i>Chelating Agent</i>			
EDTA		63, 64	
<i>Dyes</i>			
Acid orange 7		65-67	65
Acid red 88		65	
Acid red 151		65	
Acid red B (14)		68	

Acid yellow 36		65, 69	69
Methylene blue		70-76	75, 76
<i>Endocrine Disruptors</i>			
Bisphenol A		77-80	77, 78, 80
Bisphenol F		81	
17 α -Ethinylestradiol (EE2)		82-86	
17 β -Estradiol (E2)		83, 87-89	87, 89
Estriol (E3)		83	
Estrone (E1)		83	

<i>Flame Retardant</i>			
Tetrabromobisphenol A		90	90
<i>Pesticides</i>			
Atrazine		91-94	91-94
Glyphosate		95, 96	95
2-Mercaptobenzothiazole		97-99	97
<i>Other Pharmaceuticals</i>			
Acetaminophen		100	100
Carbamazepine		101	
Diclofenac		52, 102, 103	102, 103
Naproxen		52, 104	104
<i>Surfactants</i>			
4- <i>n</i> -Nonylphenol		105	105

4- <i>tert</i> -Octylphenol		105	105
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