

Table 4a. Toxicity of Copper to Freshwater Plants

Species	Method ^a	Chemical	Hardness (mg/L as CaCO ₃)	Duration	Effect	Result ^b (Total µg/L)	Reference
Blue-green alga, <i>Anabaena flos-aqua</i>	S,U	Copper sulfate	65.2	96 hr	EC75 (cell density)	200	Young and Lisk 1972
Blue-green alga, <i>Anabaena variabilis</i>	S,U	Copper sulfate	65.2	-	EC85 (wet weight)	100	Young and Lisk 1972
Blue-green alga, <i>Anabaena</i> strain 7120	-	-	-	-	Lag in growth	64	Laube et al. 1980
Blue-green alga, <i>Chroococcus paris</i>	S,U	Copper nitrate	54.7	10 days	Growth reduction	100	Les and Walker 1984
Blue-green alga, <i>Microcystis aeruginosa</i>	S,U	Copper sulfate	54.9	8 days	Incipient inhibition	30	Bringmann 1975; Bringmann and Kuhn 1976, 1978a,b
Alga, <i>Ankistrodesmus braunii</i>	-	-	-	-	Growth reduction	640	Laube et al. 1980
Green alga, <i>Chlamydomonas</i> sp.	S,U	Copper sulfate	68	10 days	Growth inhibition	8,000	Cairns et al. 1978
Green alga, <i>Chlamydomonas reinhardtii</i>	S,M,T	-	90 - 133	72 hr	NOEC (deflagellation)	12.2-49.1	Winner and Owen 1991a
Green alga, <i>Chlamydomonas reinhardtii</i>	S,M,T	-	90 - 133	72 hr	NOEC (cell density)	12.2-43.0	Winner and Owen 1991a
Green alga, <i>Chlamydomonas reinhardtii</i>	F,M,T	-	24	10 days	EC50 (cell density)	31.5	Schafer et al. 1993
Green alga, <i>Chlorella pyrenoidosa</i>	S,U	-	-	96 hr	ca. 12 hr lag in growth	1	Steeman-Nielsen and Wium-Andersen 1970
Green alga, <i>Chlorella pyrenoidosa</i>	S,U	-	54.7	-	Growth inhibition	100	Steeman-Nielsen and Kamp-Nielsen 1970
Green alga, <i>Chlorella pyrenoidosa</i>	S,U	Copper sulfate	365	14 days	EC50 (dry weight)	78-100	Bednarz and Warkowska-Dratnal 1985
Green alga, <i>Chlorella pyrenoidosa</i>	S,U	Copper sulfate	36.5	14 days	EC50 (dry weight)	78-100	Bednarz and Warkowska-Dratnal 1985
Green alga, <i>Chlorella pyrenoidosa</i>	S,U	Copper sulfate	3.65	14 days	EC50 (dry weight)	78-100	Bednarz and Warkowska-Dratnal 1983/1984
Green alga, <i>Chlorella saccharophila</i>	S,U	Copper chloride	-	96 hr	96-h EC50	550	Rachlin et al. 1982
Green alga, <i>Chlorella vulgaris</i>	S,U	Copper sulfate	2,000	96 hr	Growth inhibition	200	Young and Lisk 1972
Green alga, <i>Chlorella vulgaris</i>	S,U	Copper chloride	-	33 days	EC20 (growth)	42	Rosko and Rachlin 1977
Green alga, <i>Chlorella vulgaris</i>	F,U	Copper sulfate	-	96 hr	EC50 or EC50 (cell numbers)	62	Ferard et al. 1983
Green alga, <i>Chlorella vulgaris</i>	S,M,D	Copper sulfate	-	96 hr	IC50	270	Ferard et al. 1983
Green alga, <i>Chlorella vulgaris</i>	S,M,T	Copper chloride	-	96 hr	EC50 (cell density)	200	Blaylock et al. 1985
Green alga, <i>Chlorella vulgaris</i>	S,U	Copper sulfate	17.1	7 days	15% reduction in cell density	100	Bilgrami and Kumar 1997

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Green alga, <i>Scenedesmus quadricauda</i>	S,U	Copper sulfate	68	10 days	Growth reduction	8,000	Cairns et al. 1978
Green alga, <i>Scenedesmus quadricauda</i>	S,U	Copper sulfate	181	7 days	LOEC (growth)	1,100	Bringmann and Kuhn 1977a, 1978a,b, 1979, 1980a
Green alga, <i>Selenastrum capricornutum</i>	S,U	Copper chloride	14.9	14 days	EC50 (cell volume)	85	Christensen et al. 1979
Green alga, <i>Selenastrum capricornutum</i>	S,U	Copper chloride	14.9	7 days	LOEC (growth)	50	Bartlett et al. 1974
Green alga, <i>Selenastrum capricornutum</i>	S,M,T	Copper chloride	24.2	96 hr	EC50 (cell count)	400	Blaylock et al. 1985
Green alga, <i>Selenastrum capricornutum</i>	S,U	Copper sulfate	9.3	96 hr	EC50 (cell count)	48.4	Blaise et al. 1986
Green alga, <i>Selenastrum capricornutum</i>	S,U	Copper sulfate	9.3	96 hr	EC50 (cell count)	44.3	Blaise et al. 1986
Green alga, <i>Selenastrum capricornutum</i>	S,U	Copper sulfate	9.3	96 hr	EC50 (cell count)	46.4	Blaise et al. 1986
Green alga, <i>Selenastrum capricornutum</i>	S,U	Copper chloride	15	2-3 wk	EC50 (biomass)	53.7	Turbak et al. 1986
Green alga, <i>Selenastrum capricornutum</i>	S,U	Copper sulfate	14.9	5 days	Growth reduction	58	Nyholm 1990
Green alga, <i>Selenastrum capricornutum</i>	S,U	Copper sulfate	9.3	96 hr	EC50 (cell count)	69.9	St. Laurent et al. 1992
Green alga, <i>Selenastrum capricornutum</i>	S,U	Copper sulfate	9.3	96 hr	EC50 (cell count)	65.7	St. Laurent et al. 1992
Green alga, <i>Selenastrum capricornutum</i>	S,U	Copper sulfate	24.2	96 hr	EC50 (cell count)	54.4	Radetski et al. 1995
Green alga, <i>Selenastrum capricornutum</i>	R,U	Copper sulfate	24.2	96 hr	EC50 (cell count)	48.2	Radetski et al. 1995
Green alga, <i>Selenastrum capricornutum</i>	S,U	Copper sulfate	16	96 hr	EC50 (cell density)	38	Chen et al. 1997
Algae, mixed culture	S,U	Copper sulfate	-	-	Significant reduction in blue-green algae and nitrogen fixation	5	Elder and Home 1978
Diatom, <i>Cyclotella meneghiniana</i>	S,U	Copper sulfate	68	10 days	Growth inhibition	8,000	Cairns et al. 1978
Diatom, <i>Navicula incerta</i>	S,U	Copper chloride	-	96 hr	EC50	10,429	Rachlin et al. 1983
Diatom, <i>Nitzschia linearis</i>	-	-	-	5 day	EC50	795-815	Academy of Natural Sciences 1960; Patrick et al. 1968
Diatom, <i>Nitzschia palea</i>	-	-	-	-	Complete growth inhibition	5	Steeman-Nielsen and Wium-Andersen 1970
Duckweed, <i>Lemna minor</i>	F	-	-	7 day	EC50	119	Walbridge 1977
Duckweed, <i>Lemna minor</i>	S,U	Copper sulfate	-	28 days	Significant plant damage	130	Brown and Rattigan 1979

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Duckweed, <i>Lemna minor</i>	S,U	-	0	96 hr	EC50 (frond number)	1,100	Wang 1986
Duckweed, <i>Lemna minor</i>	S,U	Copper sulfate	78	96 hr	EC50 (chlorophyll a reduction)	250	Eloranta et al. 1988
Duckweed, <i>Lemna minor</i>	R,M,T	Copper nitrate	39	96 hr	Reduced chlorophyll production	24	Taraldsen and Norberg-King 1990
Eurasian watermilfoil, <i>Myriophyllum spicatum</i>	S,U	-	89	32 days	EC50 (root weight)	250	Stanley 1974

^a S=Static; R=Renewal; F=Flow-through; M=Measured; U=Unmeasured; T=Total metal conc. measured; D=dissolved metal conc. measured.

^b Results are expressed as copper, not as the chemical.