

ANALYSIS OF RESULTS OF FIELD TESTS: EFFECT OF SOIL CHARACTERISTICS AND CLIMATIC CONDITIONS ON CORROSION OF COPPER

National Bureau of Standards Tests (Table III)

Drainage.—The worst cases of corrosion occurred in soils with very poor drainage, whereas in well drained soils corrosion was always slight.

Moisture Equivalent. (Defined as percentage of water retained by a sample, initially saturated, subjected to a centrifugal force of 1000 × gravity).—High moisture equivalent is usually associated with very poor drainage and a high proportion of humus, a combination favourable to severe corrosion. But high moisture equivalent is not a necessary feature of a corrosive soil; for instance, the most aggressive soil, No. 67, cinders, has one of the lowest moisture equivalents, whereas in soils Nos. 27 and 8 the moisture equivalents are fairly high and yet corrosion is almost negligible.

Annual Rainfall.—In most cases this lies between 30 in. and 60 in. and within these limits appears to have little effect. It should be remembered that at some of the sites where the annual rainfall is heavy, much of it may fall in a few days and largely run off the surface, so that the subsoil is comparatively dry for a large part of the year.

At most of the sites where the annual rainfall is low (21 in. and under), the soil is alkaline. It is difficult to account for the limited rate of corrosion at some of these sites (e.g. Nos. 45, 8, 23), where the conditions are otherwise favourable to corrosion, except by the presumption that the low rainfall, and the rapid run-off of what does fall, leaves the subsoil almost dry. Soil No. 64, however, is evidently not rendered innocuous by low rainfall, so the evidence is not conclusive. In any case, while more or less desert soils of this type are common in the U.S.A. and other countries, they are unknown in this country. Corrosion is not likely to be held up long for lack of rain anywhere in Britain.

Mean Temperature.—Any effects of temperature are masked by the more marked effects of other conditions. Many of the mean temperatures given must cover widely different summer and winter temperatures, making it still more difficult to draw any inferences.

Sulphate and Chloride Contents.—Very high sulphate content (over 30 p.p. 100,000) and/or chloride content (over 10 p.p. 100,000) is in every case associated with very poor drainage and high moisture equivalent; and this combination, which usually occurs in soils containing considerable humus, appears to be mainly responsible

Table III. NATIONAL BUREAU OF STANDARDS FIELD TESTS ON COPPER, LEAD, STEEL AND CAST IRON

Average corrosion rate = Average rate of reduction of mean thickness in thousandths of an inch per year, calculated from loss of weight.
Maximum pitting rate = Average rate of penetration at deepest pit, in thousandths of an inch per year.

SOIL		COPPER			LEAD			STEEL			CAST IRON			CHARACTERISTICS OF SOIL AND CLIMATE												
No.	Type	Years buried	Average corrosion rate	Maximum pitting rate	Years buried	Average corrosion rate	Maximum pitting rate	Years buried	Average corrosion rate	Maximum pitting rate	Years buried	Average corrosion rate	Maximum pitting rate	Mean temp. ° F.	Annual rainfall ins.	Drainage	Moisture per cent.	pH	Acidity	Resistivity	Analysis of water extract, parts per 100,000 of soil.					
																					Na and K as Na	Ca	Mg	HCO ₃	Cl	SO ₄
67	Cinders	9.2	1.58	5.9 S	4.0	3.22	26.0	9.2	9.67	16.6	9.2	Destroyed	27.1†	46	30	VP	11	8.0	Alk.	455	0.8	3.0	0.5	0.6	0.08	2.9
43	Tidal marsh	8.0	0.81	S	12.0	0.02	1.1	12.0	2.13	7.8	12.0	2.51	15.6	52	43	VP	55	3.1	37	60	45.1	5.2	9.5	0	43.3	37.0
63	Tidal marsh	9.6	0.62	0.8 S	4.0	0.004	4.5	9.6	1.44	5.6	9.6	1.09	11.9	66	45	VP	47	2.9	100	84	33.6	6.8	4.0	0	12.7	36.6
60	Peat	9.2	0.91	4.2 S	4.0	0.07	3.8	9.2	2.77	2.9	9.2	3.82	18.9†	49	37	VP	43	2.6	297	218	2.9	11.0	2.9	0	0	56.7
33	Peat	8.0	0.17	1.0	—	—	—	11.7	1.81	8.3	11.7	2.47	13.6	46	30	VP	73	6.8	36	800	1.5	7.3	4.1	—	2.3	2.1
58	Muck	9.5	0.29	1.3	4.0	0.64	7.0	9.5	2.61	11.6	9.5	3.59	26.3†	69	57	VP	58	4.0	79	712	2.0	2.2	1.3	0	0.5	2.5
29	Muck	8.0	0.16	<0.8	10.1	0.36	3.4	12.0	2.27	11.1†	12.0	3.90	16.2	69	57	VP	34	4.2	28	1270	2.2	1.9	1.6	0	1.7	2.3
45	Alkali soil	8.0	0.04	1.0	11.7	0.02	2.0	11.7	1.23	7.5	11.7	2.00	11.5	47	15	P	15	7.4	Alk.	263	8.2	3.7	0.7	0.2	0.2	12.0
64	Clay	9.2	0.60	1.7	4.0	0.05	4.0	9.2	Destroyed	16.7†	9.2	Destroyed	27.2†	58	16	VP	41	8.3	Alk.	62	28.1	2.3	0.8	0.9	28.8	0.3
56	Clay	9.4	0.11	<0.7	4.0	0.12	9.2	9.4	4.67	16.4†	9.4	Destroyed	26.6†	69	49	P	29	7.1	4	406	3.1	0.7	0.5	0.8	1.6	3.0
61	Clay	9.5	0.05	0.8	4.0	0.58	9.8	9.5	0.93	10.1	9.5	1.26	8.2	69	57	P	31	5.9	9	943	0.7	0.7	0.3	0.7	0.1	0.9
27	Clay	13.6	0.016	<0.4	15.7	0.05	2.0	17.6	0.82	3.9	15.5	0.68	8.3	67	56	P	43	6.6	4	570	0.5	1.9	1.1	2.0	0.1	1.5
28	Clay adobe	8.0	0.11	<0.8	9.6	0.07	1.0	9.6	2.59	15.0†	9.6	3.84	17.7	61	10	P	25	6.8	—	408	1.5	0.06	0.2	0.1	1.0	0.9
5	Clay adobe	13.4	0.04	0.6	15.6	0.45	7.2	17.5	0.70	3.0	17.5	1.06	7.8	56	23	P	29	7.0	6	1346	0.9	0.5	0.1	0.7	0.03	0.2
3	Clay loam	8.0	0.04	<0.8	10.0	0.06	1.8	12.1	0.60	5.1	12.1	0.57	12.8	61	48	G	29	5.2	12	30000	—	—	—	—	—	—
8	Clay loam	8.0	0.03	1.4	11.8	0.06	1.0	11.8	0.97	6.9	11.8	3.06	17.8	49	21	P	37	7.6	Alk.	350	1.4	1.7	2.6	0.7	0.01	4.4
25	Clay loam	8.0	0.016	<0.4	11.7	0.03	2.4	11.7	0.42	3.9	11.7	0.51	6.8	46	30	F	26	7.2	5	2980	0.2	0.7	0.4	1.0	0.03	0.1
36	Sandy loam	13.6	0.26	<0.4	15.7	0.03	1.4	17.7	0.30	2.8	17.7	0.16	5.1	64	53	G	14	4.5	5	11200	—	—	—	—	—	—
10	Sandy loam	13.2	0.12	0.6	12.0	0.09	1.3	12.0	0.60	3.7	12.0	0.79	5.3	50	41	F	13	6.6	4	7460	—	—	—	—	—	—
12	Fine sandy loam	8.0	0.40	1.5 S	15.6	0.12	2.8	17.5	0.49	4.2	17.5	0.36	4.7	62	15	F	12	7.1	2	3190	0.4	0.5	0.2	0.4	0	0.1
16	Fine sandy loam	8.0	0.08	2.6	—	—	—	12.0	0.97	5.3	12.0	1.36	14.3	67	61	F	22	4.4	12	8290	—	—	—	—	—	—
37	Fine sand	8.0	0.23	1.6	—	—	—	12.0	1.00	6.7	12.0	2.14	8.0	69	47	P	7	3.8	15	11200	—	—	—	—	—	—
31	Fine sand	13.7	0.012	<0.4	15.7	0.019	1.0	17.7	0.35	3.0	17.7	0.26	3.4	69	47	G	3	4.7	2	20500	—	—	—	—	—	—
66	Fine gravelly loam	9.2	0.08	<0.9	4.0	0.025	8.5	9.2	3.08	16.7	9.2	0.73	16.5	70	8	G	16	8.7	Alk.	232	6.6	0.5	0.2	0.7	2.8	3.0
6	Gravelly sandy loam	13.3	0.014	<0.4	15.5	0.018	1.8	17.5	0.16	1.1	17.5	0.08	1.5	51	34	G	12	5.9	13	45100	—	—	—	—	—	—
4	Loam	8.0	0.03	1.3 M	12.0	0.19	4.2	12.0	0.84	6.8	12.0	1.48	8.2	54	40	F	22	5.6	8	6670	—	—	—	—	—	—
35	Loam	8.0	0.02	<0.7 M	15.6	0.02	2.4	17.5	0.16	1.2	17.5	0.26	4.6	62	15	G	18	7.3	6	2060	0.7	0.7	0.5	1.1	0.06	0.4
23	Silt loam	8.0	0.18	1.6	—	—	—	12.1	2.54	12.5†	12.1	4.76	25.8†	65	6	P	25	9.4	Alk.	278	8.4	0.4	0.2	1.9	1.1	5.6
1	Silt loam	8.1	0.08	1.1	11.6	0.18	9.6†	11.6	1.22	7.2	11.6	1.89	15.2	49	34	P	29	7.0	11	1215	0.7	0.2	0.4	0.1	0.1	0.8
20	Silt loam	8.1	0.05	1.4	11.6	0.28	4.4	11.6	0.80	5.5	11.6	1.10	8.9	49	34	P	22	7.5	1	2870	0.2	0.5	0.2	0.5	0	0.2
19	Silt loam	8.0	0.05	0.9	11.6	0.04	1.3	11.6	0.46	5.6	11.6	0.60	13.0	50	32	G	28	4.6	11	1970	0.4	0.3	0.4	0.2	0.03	0.5
18	Silt loam	8.0	0.010	U M	11.7	0.016	0.8	11.7	0.35	3.5	11.7	0.47	9.0	51	28	G	28	7.3	1	1410	0.3	0.6	0.2	0.9	0	0.2

M = Surface roughened, but no definite pitting.
U = Unaffected by corrosion.
S = Severe uniform corrosion; depth of pits uncertain.
† = Perforated.
G = good; F = fair; P = poor; VP = very poor; Alk. = alkaline.
See also Appendix A, page 41.
N.B.—Where two letters (or figures and a letter) appear under "Maximum pitting rate," they represent different results obtained on two or more specimens.