

TABLE A.—EXAMPLES OF WATER ANALYSES.

Parts per 100,000.

WATER.	Source, Locality, or Date.	Physical Characters.	Total Solids.	Chlorine.	Free Ammonia.	Albaminoid Ammonia.	Nitrogen as Nitrates and Nitrites.	Nitrites.	Total combined Nitrogen.	Percentage of Nitrogen Oxidised.	Phosphates.	Total Hardness.	Permanent Hardness.	First Oxygen Consumed.†	Second Oxygen Consumed.†	Organic Carbon.	Organic Nitrogen.	REMARKS.
Rainwater from Tank	Guildford ..	Inodorous, nearly colourless, not clear.	2.9	0.55	0.45	0.256	No nitrate.	Trace	0.082	Trace to nitrite.	None	Slight	..	..	..	..	A fair sample of rainwater as ordinarily collected.	
Average of 71 Rainwaters	Rothamstead ..	.. ..	3.42	0.33	0.49	..	0.007	..	0.068	10.3	..	0.5	..	..	0.095	0.021	Solids ranged from 0.62 to 8.58.	
Rainwater, Land's End	Cornwall ..	Slightly turbid ..	42.8	21.8	None	..	0.020	..	0.054	37	..	10.0	..	..	..	1.31	0.084	Mixed with sea-spray.
Town Rain	London ..	Slightly sooty ..	3.8	0.6	0.110	0.032	0.008	Distinct	0.148	5.4	..	1.5	1.5	..	..	3.83	0.040	Trace of free sulphuric acid. Arsenic 0.20 (Frankland).
LONDON WATERS. §																		
River at Sunbury (intakes)	Thames ..	Turbid ..	31.24	1.8	0.002	..	0.305	Distinct	0.356	86	..	..	..	..	..	0.314	0.049	Microbes per c.c. 18,330.
River at Hampton ( .. ) ..	.. ..	Brownish turbid ..	29.74	1.9	0.012	0.0280	0.273	..	0.335	81.5	S.T.	21.5	5.0	0.064	0.140	0.258	0.052	278.
Chelsea Water Co. .. ..	.. ..	Clear, pale yellow ..	29.92	1.8	None	0.0098	0.236	V.F.T.	0.276	85.5	V.S.T.	23.0	4.6	0.040	0.094	0.177	0.035	38.
West Middlesex Water Co. .. ..	.. ..	Clear, pale amber ..	30.1	1.8	..	0.0124	0.254	None	0.272	93.4	..	22.4	4.4	0.069	0.160	0.150	0.018	56.
Southwark .. ..	.. ..	Clear, straw-coloured. ..	29.58	1.8	Trace	0.0100	0.225	V.F.T.	0.241	93.4	..	22.4	4.5	0.090	0.126	0.170	0.040	.. ..
Grand Junction .. ..	.. ..	Clear, pale amber ..	27.96	1.9	0.003	0.0060	0.211	None	0.237	92.8	..	21.7	4.1	0.077	0.099	0.179	0.026	270.
Lambeth .. ..	.. ..	.. ..	29.1	1.9	None	0.0074	0.237	..	0.261	90.8	..	22.1	4.4	0.020	0.086	0.162	0.035	160.
Intake New River Co. .. ..	.. ..	Turbid, pale yellow ..	32.3	1.7	0.002	0.0216	0.324	V.F.T.	0.344	94.2	..	25.0	6.5	0.030	0.144	0.099	0.018	8,660.
New River Co.'s Supply .. ..	.. ..	.. &c. ..	28.5	1.8	0.0003	0.0050	0.287	None	0.295	97.3	..	24.0	6.0	0.053	0.077	0.056	0.008	28.
Intake East London Co.	Lea ..	Turbid, pale brown ..	40.9	2.3	0.030	0.0221	0.255	..	0.346	73.7	S.T.	26.6	6.4	0.048	0.150	0.295	0.066	23,010.
East London Co.'s Supply .. ..	.. ..	.. &c. ..	32.24	2.1	0.004	0.0140	0.285	..	0.309	92.2	V.S.T.	23.6	6.1	0.047	0.077	0.135	0.024	214.
Kent Co., New Cross	Wells in Chalk ..	Clear, bluish ..	32.9	2.4	None	0.0006	0.227	..	0.235	96.6	None	24.5	7.0	0.004	0.009	0.067	0.008	8.
.. ..	.. ..	.. ..	39.0	2.0	..	0.0010	0.450	..	0.461	97.6	Trace	..	..	..	..	0.072	0.011	.. ..
.. ..	Deptford ..	.. ..	38.8	2.3	..	0.0015	0.320	..	0.345	95.4	None	29.2	7.1	0.006	0.013	0.069	0.016	11.
Midstream, Crossness (average)	Thames ..	Turbid, brownish ..	.. ..	.. ..	0.102	0.0394	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..	"Organic elements" 1.221.	
SEWAGE EFFLUENTS.																		
Average London Sewage .. ..	.. ..	.. ..	.. ..	10.5	4.52	0.547	None	.. ..	4.26	0	.. ..	.. ..	.. ..	.. ..	4.30	.. ..	.. ..	.. ..
Raw Sewage, Yeovil	June 15, 1896 ..	Very turbid and fetid.	80.6	12.64	9.00	1.135	.. ..	.. ..	9.39	0	Very heavy.	.. ..	.. ..	.. ..	5.86	.. ..	.. ..	A blackish flocculent sediment.
.. ..	Weybridge ..	June 12, 1896 ..	84.6	10.0	10.15	1.05	.. ..	.. ..	10.21	.. ..	.. ..	.. ..	.. ..	.. ..	4.00	.. ..	.. ..	.. ..
.. ..	.. ..	Coventry (after treatment with Alum, &c.) ..	63.6	7.01	0.34	0.104	No nitrate.	Strong	0.480	Distinct to nitrite.	Heavy	.. ..	.. ..	.. ..	1.87	.. ..	.. ..	Sewage diluted, and partly oxidised.
Fish Manures Factory Effluent, Wembley	June 26, 1896 ..	Brown colour, very offensive.	245.8	16.7	52.0	2.50	None	None	47.1	0	.. ..	.. ..	.. ..	.. ..	9.36	.. ..	.. ..	Contained trimethylamine(?) and fish-oil.
Sewage Farm Effluent, Wembley	June 22, 1896 ..	Blackish, turbid, and fetid.	133.4	12.6	0.85	0.63	0.75	Very strong.	1.54	48.7	.. ..	.. ..	.. ..	.. ..	1.79	.. ..	.. ..	From sewage farm. Nitrification in progress.
Sewage Effluent, Aylesbury	June 2, 1894 ..	Cloudy, strong sewage odour.	80.0	8.9	4.4	1.3	0.08	Trace	5.95	1.3	.. ..	.. ..	.. ..	.. ..	7.83	.. ..	.. ..	A bad effluent. Nitrification very sluggish.
Croydon Sewage Farm Effluent	April 26, 1895 ..	Nearly clear ..	46.0	3.25	4.55	0.07	0.88	Very strong.	1.40	63	.. ..	.. ..	.. ..	.. ..	1.29	.. ..	.. ..	Shows active nitrification in progress. A good effluent.

* This column has reference to the remarks on p. 245. In rainwater, the oxidised nitrogen has mainly been derived from the air. "Second Oxygen consumed," the maximum amount obtained under the conditions used by the analyst.

† The "First Oxygen consumed" indicates the loss from permanganate in a short time (5 minutes or 15 minutes, as the case may be). § These vary from time to time. For complete series, see reports of Metropolitan Water Examiners, also London County Council Report, 1896.

|| This and the next furnish a good example of the improvement effected by subsidence and filtration.

TABLE A.—EXAMPLES OF WATER ANALYSES—Parts per 100,000—*continued.*

WATER.	Source, Locality, or Date.	Physical Characters.	Total Solids.	Chlorine.	Free Ammonia.	Ammonium Ammonia.	Nitrogen as Nitrites and Nitrates.	Nitrites.	Total combined Nitrogen.	Percentage of Nitrogen Oxidised.	Phosphates.	Total Hardness.	Permanent Hardness.	First Oxygen Consumed.	Second Oxygen Consumed.	Organic Carbon.	Organic Nitrogen.	REMARKS.			
Sewage Effluent, Ripley Green, Guildford.	January 13, 1896	..	39.5	9.11	.300	.086	None	Very strong.	.414	To nitrite only.	Heavy trace.	..	..	1.18	..	..	Nitrification not satisfactory.			
Farm Effluent, Ripley Green, Guildford.	..	Distinct sewage odour.	59.9	8.48	1.42	.128	..	None	1.41	0	Very strong.	..	..	1.52	..	..	In bad condition. No nitrification.			
Sewage Farm Effluent, Birmingham.	77.7	7.05	.380	..	.441	..	.908	48.5	..	..	..	..	..	..	Suspended matter: organic .28, mineral .76. Nitrification active.				
Fresh Sewage: average from 16 Water Closet Towns.	(Frankland)	..	72.2	10.66	6.70	..	.003	..	7.80	0.04	..	..	..	..	..	..	Suspended matter: organic 24.2, mineral 20.5.			
Fresh Sewage from 15 Midden Towns.	82.4	11.54	5.43	..	None	..	6.50	0	..	..	..	..	..	..	Suspended matter: organic 17.8, mineral 21.3.				
River Avon, Coventry	February 6, 1896.	Turbid, marshy odour.	51.6	2.2	Trace	.032	.025	Strong	.079?	31.3	H.T.	..	..	.240	..	Polluted with sewage, altered by flow and vegetation.			
UPLAND SURFACE WATER.																					
River Exe above Town, May 28, 1895.	Exeter	..	Clear, very pale brownish.	9.0	1.3	None	.011	.107	V.F.T.	.133	80.5	V.F.T.	4.21	4.14	..	.270	.400	.063 Peaty matter.			
Derbyshire	Millstone Grit	..	Brownish, slightly turbid.	7.9	0.95	Trace	.009	.035	None	.060	58.3	None	3.5	3.0	..	.380	.250	.025 Very peaty.	
Lower London Tertiaries, &c.	Bagshot Beds	..	Nearly clear	8.4	2.06	.004	.010	.007	V.F.T.	.059	11.8	V.S.T.	3.8	3.5	..	.220	.379	.048 Very little nitrification.	
Ripon, the Kex Beck	Mountain Lime-stone.	..	Brownish, clear	17.7	1.24	.001	.006	.011	None	.059	18.6	None	12.7	7.0	..	.370	.047	Peaty.	
Water from Cultivated Land	Magnesian Lime-stone.	..	Slightly turbid	17.8	1.40	.001	.004	None	..	.037	0	..	14.7	8.3	..	.172	.036	Highly polluted with manures.	
Shrewsbury, shallow Spring	Calcareous Soil	..	Turbid, brownish, faint odour.	110.4	12.75	.030	..	1.005	..	1.337	75.2	H.T.	67.3	42.1	..	..	1.34	.307	
	New Red Sandstone.	..	Clear, nearly colourless.	38.5	2.30	.001	..	.449	..	.466	96.3	..	31.3	10.9	..	..	.040	.016 Probably polluted with surface drainage.	
DEEP WELLS.																					
Bore Hole, 575 feet, Coventry (see also Kent Waters above).	Red Sandstone	..	Clear, nearly colourless.	796.9	117.7	.100	..	.119	..	.239	49.8	..	151.5	36.3	..	..	.041	.036 Example of a saline and undrinkable water.		
Artesian Well	Chalk under London Clay.	..	Clear, nearly colourless.	106.7	38.8	.118	..	.645	..	.681	94.7	..	48.5	25.4	..	..	.195	.067 High mineral constituents. Shows the difference mentioned at p. 279.	
SPRINGS.																					
From Granite and Gneiss Rocks	5.94	1.69	.001	..	.166	None	.115	92.2	None	3.0	2.6	..	..	.042	.008	
Lower Greensand and Gault Clay	Shefford, March 13, 1896.	..	Clear and colourless.	99.4	12.4	Trace	.0022	.090	Trace	.904	99.5	Trace	..	..	..	..	..	A bad water from its mineral constituents. Shows some signs of organic pollution.	
Weald Clay	Charlwood	..	Brown sediment	428.6	40.0	.020	.080	Trace	None	.157	Trace	..	21.8	..	..	.200	..	Alkaline, unfit for drinking.	
Oolite	Clear, colourless	30.3	1.55	.001	.003	.402	..	.414	.97	None	24.4	6.2	..	..	.043	.011 A good water.	
A SHALLOW WELL	Deep yellow brown, clear.	112.0	8.8	.252	.013	4.61	Abundant	4.85	95	H.T.	57.0	33.0	.084	.112	Badly polluted.

* This column has reference to the remarks on p. 245. In rainwater, the oxidised nitrogen has mainly been derived from the air.

† The "First Oxygen consumed" indicates the loss from permanganate in a short time (5 minutes or 15 minutes, as the case may be); "Second Oxygen consumed," the maximum amount obtained under the conditions used by the analyst.

TABLE B.
COMPOSITION OF BOILER INCRUSTATIONS FROM DIFFERENT WATERS.

Number	...	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16																
		Sea Water.		Breckish Water.		River Water.		Carlsle.		Wells.		Dumbar.		Stouff.		Towm Shulburgh.		Fadimburgh.		Springs.		Pits & Quarries.		Face-Press.		Furnaces.		Grafton.		Quarry.		An Acid.		Wulcr.
Pressure in lbs. per sq. in.	5	10	20	25(2)	60	80
CaCO ₃	...	2.00	3.44	0.34	0.97	43.65	75.85	75.92	8.20	81.45	32.16	25.62	62.95	50.04	1.22	17.31	2.20	
CaSO ₄	...	34.00	69.77	72.85	85.53	34.78	3.68	3.16	85.01	1.63	5.64	5.92	20.80	29.76	78.32	53.76	
Mg(OH) ₂	...	58.00	22.50	18.83	3.39	4.34	2.56	...	4.36	...	8.10	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
MgCO ₃
Na salts
NaCl	...	Trace	0.99	2.16	2.79	0.56	0.45	...	0.84	...	Trace	Trace	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Fe ₂ O ₃ , Al ₂ O ₃ , and Ca ₃ (PO ₄) ₂ ...	1.33	1.36	2.40	0.32	3.44	2.96	0.52	0.52	2.44	7.46	5.04	2.48	2.36	4.64	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
SiO ₂	...	Trace	0.16	0.80	1.10	7.52	7.66	4.94	1.91	0.87	16.94	5.26	3.76	4.28	3.22	4.36	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Organic matter	4.67	1.78	2.62	2.62	4.16	3.20	1.53	1.53	1.53	Trace	4.65	3.64	0.49	1.04	0.69	0.64	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88				
Moisture		

NOTES.—These analyses are only comparative in a general sense, as they were done under different circumstances. They, however, furnish good examples of the effects of varying conditions. Nos. 1, 2, 3, 4 show the increasing proportion of calcium sulphate precipitated with an increasing pressure, and therefore temperature. In Nos. 6, 7, 9, 10, 12, the waters were of the carbonate of lime class, in which the temporary hardness is predominant. In Nos. 8, 14, 15, the waters had a high permanent hardness, due to sulphate of lime. No. 10 is a magnesian water. The high amount of silica is remarkable, also the action on iron. No. 16 shows the action of a soft and acid water on iron. The small quantity of carbonate of lime has probably been protected by the iron scale. As boiler crusts usually contain magnesium hydrate only, the magnesium found in some of the above analyses must be due to the absorption of carbonic acid from the air by the crust after removal.

WATER PURIFICATION.

TABLE C. COMMON ELEMENTS AND THEIR COMPOUNDS OCCURRING IN CONNECTION WITH WATER.

Chief Compounds and their Synonyms and Formulae.			
A.—NON-METALS.			
Grases.			
Oxygen	O	16	Free oxygen, O_2 , in air, and dissolved in water, H_2O . Basic oxides, oxy-acids, and almost all organic matter. Ozone, O_3 . Peroxide of hydrogen, H_2O_2 .
Hydrogen	H	1	Product of putrefaction. Water, H_2O . Hydrates. All acids.
Nitrogen	N	14	Free, N_2 , in air, and dissolved in water. Product of some bacteria. Nitric acid, HNO_3 , and nitrates. Nitrous acid, HNO_2 , and nitrites. Ammonia, NH_3 , and its salts. Nitrogenous organic matter, animal and vegetable.
Chlorine	Cl	35.4	Free, Cl_2 , only artificially, as a disinfectant. Common salt, sodium chloride, $NaCl$; hydrochloric or "muriatic" acid, "spirits of salts," HCl ; chlorides of all metals.
Solids.			
Sulphur	S	32	Sulphuretted hydrogen or hydric sulphide, H_2S . Ammonium sulphide, NH_4HS . Ferrous sulphide or proto-sulphide of iron, FeS . Sulphates. Organic sulphur compounds, including albumen, &c.
Carbon	C	12	Free in charcoal, coke, soot, &c. Combined in "carbonic acid," CO_2 , more correctly carbon dioxide or carbonic anhydride. Carbonates (see lime, magnesia, &c.). All organic matter. Marsh gas or methane, CH_4 , among products of putrefaction. Phosphates (see the metals).
Phosphorus	P	31	Never free in nature. Phosphoretted hydrogen, PH_3 , from putrefaction. Phosphates (see the metals).
Silicon	Si	28	Never free in nature. Silica, SiO_2 , in waters, and along with silicates in rocks and soils.
Sodium	Na	23	Caustic soda, sodium hydrate, or "soda," $NaOH$. Anhydrous sodium carbonate, the neutral or normal carbonate, Na_2CO_3 . Crystallized sodium carbonate, "washing soda," "soda crystals," often simply called "soda," Na_2CO_3 , 10 H_2O . Soda ash, black ash, or "ball soda," very impure Na_2CO_3 . Sodium hydrogen carbonate, acid carbonate, hydro-carbonate, or bicarbonate, often called "carbonate of soda," $NaHCO_3$. Sodium chloride, common salt, $NaCl$. Sodium nitrate, $NaNO_3$. Nitrite, $NaNO_2$. Sulphate, Na_2SO_4 . Sulphide, Na_2S . Disodium phosphate, common phosphate of soda, Na_2HPO_4 , 12 H_2O . Tribasic phosphate, Na_3PO_4 .
B.—METALS.			
Symbol			
Atomic weight.			

Oxygen O 16 Free oxygen, O_2 , in air, and dissolved in water, H_2O . Basic oxides, oxy-acids, and almost all organic matter. Ozone, O_3 . Peroxide of hydrogen, H_2O_2 .

Hydrogen H 1 Product of putrefaction. Water, H_2O . Hydrates. All acids.

Nitrogen N 14 Free, N_2 , in air, and dissolved in water. Product of some bacteria. Nitric acid, HNO_3 , and nitrates. Nitrous acid, HNO_2 , and nitrites. Ammonia, NH_3 , and its salts. Nitrogenous organic matter, animal and vegetable.

Chlorine Cl 35.4 Free, Cl_2 , only artificially, as a disinfectant. Common salt, sodium chloride, $NaCl$; hydrochloric or "muriatic" acid, "spirits of salts," HCl ; chlorides of all metals.

Solids.

Sulphur S 32 Sulphuretted hydrogen or hydric sulphide, H_2S . Ammonium sulphide, NH_4HS . Ferrous sulphide or proto-sulphide of iron, FeS . Sulphates. Organic sulphur compounds, including albumen, &c.

Carbon C 12 Free in charcoal, coke, soot, &c. Combined in "carbonic acid," CO_2 , more correctly carbon dioxide or carbonic anhydride. Carbonates (see lime, magnesia, &c.). All organic matter. Marsh gas or methane, CH_4 , among products of putrefaction. Phosphates (see the metals).

Phosphorus P 31 Never free in nature. Phosphoretted hydrogen, PH_3 , from putrefaction. Phosphates (see the metals).

Silicon Si 28 Never free in nature. Silica, SiO_2 , in waters, and along with silicates in rocks and soils.

B.—METALS.

Symbol

Atomic weight.

Symbol

Atomic weight.

COMMON ELEMENTS.

TABLE OF ELEMENTS—continued.

Chief Compounds and their Synonyms and Formulae.			
B.—METALS—continued.			
Potassium	K	39	Caustic potash, the hydrate or hydroxide, KOH . Carbonate, "pearlash," K_2CO_3 . Chloride, KCl . Nitrate, nitre, or saltpetre, KNO_3 . Sulphate, K_2SO_4 .
Calcium	Ca	40	Oxide, quicklime, CaO . Hydrate or hydroxide, slaked lime, $Ca(OH)_2$ or CaH_2O_2 . Carbonate, chalk, marble, limestone, $CaCO_3$. Bicarbonate, $CaCO_3CO_2$, or CaH_2CO_3 . only known in solution. Chloride, $CaCl_2$. Sulphates: anhydrite, $CaSO_4$; gypsum or selenite, $CaSO_4 \cdot 2H_2O$. Nitrate, $Ca(NO_3)_2$.
Magnesium	Mg	24	Oxide, magnesia, MgO . Hydrate, $Mg_3(PO_4)_2$. Phosphate, $Mg_3(PO_4)_2$. Sulphate, $MgSO_4$ or $Mg(H_2O_2)_7H_2O$. Carbonate, $MgCO_3$. Chloride, $MgCl_2$. Sulphide, MgS . Epsom Salts, "MgSO_4 \cdot 7H_2O. Nitrate, $Mg(NO_3)_2$.
Aluminium	Al	27.3	Oxide, alumina, Al_2O_3 . Hydrate or hydroxide, gelatinous alumina, $Al_2(OH)_6$. Sulphate, $Al_2(SO_4)_3 \cdot 18H_2O$. "Alumino-ferric," mixture of the sulphates of iron and alumina. Potash alum, $Al_2(SO_4)_3 \cdot K_2SO_4 \cdot 24H_2O$. Ammonia alum, $Al_2(SO_4)_3 \cdot (NH_4)_2SO_4 \cdot 24H_2O$. Chloride, "chloralum," Al_2Cl_6 . Clay, impure silicate of Al containing iron.
Iron, Ferrum	Fe	56	Ferric oxide, peroxide of iron, Fe_2O_3 . Ferric hydrate, $Fe_2(OH)_6$. Ferric carbonate, $FeCO_3$. Bicarbonate. Ferric chloride, perchloride of iron, Fe_2Cl_6 . Ferrous sulphate, protosulphate of iron, green vitriol or copperas, $FeSO_4 \cdot 7H_2O$. Ferric sulphate, $Fe_2(SO_4)_3$.
Manganese	Mn	55	Manganous oxide, MnO . Potassium manganate, "Condy's Green Fluid," "Crimson Salt," K_2MnO_4 . or dioxide, MnO_2 .
Lead	Pb	207	Hydrocarbonate, white lead, $PbCO_3$, $Pb(OH)_2$ (soluble as bicarbonate). Sulphate, $PbSO_4$ (insoluble). Hydrate, $Pb(OH)_2$ (somewhat soluble). Chloride, $PbCl_2$ (soluble).

The molecular weight of a compound is obtained by adding up the atomic weights of the elements in its formula.

WATER PURIFICATION.

TABLE D.
ORDER OF THE ROCKS AND CHARACTERISTICS OF WATERS DERIVED FROM THEM.

Period.	Group.	Sub-divisions.	Waters.
TERTIARY	Recent	Made Earth Vegetable Soil. Blown Sand..	Waters from vegetable soil and from made earth are polluted and highly dangerous. Waters from sand are sometimes almost pure rain water, but are often brackish. Surface waters, p. 59.
	Alluvium	Peat Glacial Drift.	Peaty and moorland waters are described at p. 142.
Post-tertiary or Pleistocene.	Nearer Tertiary or Pliocene.	Norwich Crag, Red Crag, &c.	Shelly sands, marls, and gravel, usually too porous to allow of proper filtration of the surface water that soaks into them. In some places beds of peat affect the character of the water. In the west of England open shallow wells in the drift sometimes form the chief supply of villages, but are gradually being superseded by less dangerous sources.
Lower Tertiary or Eocene.	Barton Clay	..	Absent in the London Basin. In Hampshire its sandy layers yield a good water, though not abundant.
	Bagshot Sands	..	Water mostly very soft, but often of bad taste and colour through fossil remains, lignite, &c.
	London Clay	..	Impervious to water.
	Woolwich and Reading Beds.	..	Pebble beds, sand, loam, and plastic clay. Water very various in quality, and not usually regular nor abundant in yield.
	Thanet Sands	..	Occur only in the London Basin. Water often abundant and soft, but wells liable to great fluctuations and to surface infiltration.

ORDER OF ROCKS, &c.—*continued.*

Period.	Group.	Sub-divisions.	Waters.
MESOZOIC or SECONDARY.	Upper Cretaceous.	Upper Chalk, with flints. Lower Chalk, without flints.	These strata, as is well known, yield water of great organic purity, but of considerable temporary hardness. They form large underground reservoirs of water resting on the chalk marl. Far-extending fissures have occasionally been known to convey surface pollution, but the water is usually almost free from organic matter and life. Artesian wells are frequent, as those of the Kent Company. The water from the chalk, where covered by the London clay, is not, however, good. See analysis in Table A.
	Grey Chalk	..	Contains organic matter, water often ill-tasting.
	Chalk Marl	..	Contains clayey and silicious matter and iron. Water usually inferior in a mineral sense. Arrival at these beds indicates the termination of a boring in the chalk.
	Upper Greensand	..	Derives water partially from the chalk, stopped by the gault. Supply not large, often turbid and hard, sometimes ferruginous. Its organic character varies.
	Gault Clay	..	A blue tenacious clay with pyrites and phosphatic nodules. Springs yield a scanty and inferior water.
Lower Cretaceous.	Lower Greensand	..	Contains much oxide of iron, therefore water ferruginous, and often full of sand. Strata partly marine. Beds of clay intervene. A few wells yield, however, a soft and pure water, but in limited quantity.
Walden (fresh water or fluviatile strata, specially developed in the south of England).	Weald Clay	..	No available water.
	Hastings Sand	..	Water good where in sufficient quantity.
	Purbeck Beds	..	Mainly limestone without water. The "dirt beds" convey much vegetable organic matter and an objectionable taste.

ROCK WATERS.

WATER PURIFICATION.

ORDER OF ROCKS, &c.—continued.

Period.	Group.	Sub-divisions.	Waters.
MESOZOIC or SECONDARY.	Jurassic	Portland Stone .. Portland Sand .. Kimmeridge Clay ..	Owing to the porosity of the water-bearing beds of the Oolite, the water is frequently turbid, and surface water is rare. Limestones, with hard and scanty water.
		Coral Rag and Calcareous Grit. Oxford Clay ..	Water abundant, and usually good. About 600 feet deep. Much bituminous and vegetable matter. When this stratum is reached further boring is generally inadvisable.
		Middle Oolite.	Water commonly free from organic matter, but of high temporary hardness and not plentiful. Fissures frequent, leading to danger from surface drainage.
		Kolloways Rock Bath or Great Oolite (calcareous with sandstones and clayey seams). Fuller's Earth (clay).	Stiff blue and brown clay, occasionally bituminous and pyritous, attaining in some places a thickness of 600 feet. The water is scanty, impregnated with Cu and Mg sulphates, and sometimes medicinal. This stratum, like clay beds generally, yields water above and below it.
		Lower Oolite.	A calcareous sandstone containing little water. On the whole the Oolite consists of four masses of partially permeable strata separated by thick deposits of clay, the limestones forming the ridges and the clays the valleys:— (1) Portland Oolite. Limestone and Sand, Kimmeridge Clay; (2) Calcareous Grit, Coral Rag, Oxford Clay; (3) Bath Oolite, Fuller's Earth; (4) Inferior Oolite, Lias Clay. Hence springs are numerous and abundant from the porous strata under the beds of clay. The water is usually hard, and varies from clear and palatable to very turbid. In some cases a saline taste from chloride and sulphate of sodium.

ROCK WATERS.

ORDER OF ROCKS, &c.—continued.

Period.	Group.	Sub-divisions.	Waters.
MESOZOIC or SECONDARY.	Jurassic	Inferior Oolite (calcareous freestone and grit). Lower Oolite.	Northampton Sands contain ironstone, and the water is ferruginous. Deep wells at Gloucester and Cheltenham are impregnated with sodium sulphate and chloride. At Bath they are gypseous, but not often saline. Some springs in the Mendip Hills are good and copious. Oolite waters of Yorkshire are much softer than those from the southern Oolite. Usually acid and loaded with mineral matter.
		Alum Shale .. Marlstone. Lower Lias.	Rhaetic or Infra-Lias Waters of fair quality where not medicinal.
		Upper Trias or Keuper. Middle Trias or Muschelkalk. Lower Trias or Bunter Sandstone.	The Rhaetic includes the "Bone-bed," giving ill-flavoured water containing organic matter and phosphate of lime, therefore peculiarly apt to develop organisms. The Muschelkalk is a limestone unrepresented in England. When cut off locally by thin beds of clay or by clay-filled faults the Bunter Sandstone yields excellent water, as at Wolverhampton and other places. More rarely good water is obtained from the Keuper. But, as a whole, the Trias, being a marine formation, including deposits of gypsum, rock salt, and oxide of iron, yields water unfit for drinking on account of its saline constituents (analysis, Table A).

WATER PURIFICATION.

ORDER OF ROCKS, &c.—continued.

Period.	Group.	Sub-divisions.	Waters.
PALÆOZOIC OR PRIMAR Y. (These, from their hardness, form usually mountainous districts, and are important "gathering grounds.")	Permian or "Dyas."	Magnesian Limestone or Dolomite.	Furnishes an abundant yield in places, but the water shows high permanent hardness, from the presence of lime and magnesium salts, and is apt to be salt, bitter, and unwholesome. The thickness of the strata and, therefore, depth of sinking vary very greatly, and there is also great interference from faults.
Lower New Red Sandstone.			Water organically good, but often saline and ferruginous. The beds contain large quantities of water, and yield copious springs, but the rock being extremely porous, surface contamination is frequent.
Carboniferous	Coal Measures (hot springs occur at Matlock, Buxton, and Clifton).		Water mostly scanty in quantity, and of bad quality, often ferruginous and acid. Mine waters are generally very inferior, even if treated with lime. (See p. 136.) In many cases, however, it would be desirable to economize them in reservoirs for small towns and villages, as the draining of mines sometimes dries up the wells of a district. Storage would effect considerable improvement.
	Millstone Grit	..	Supplies excellent water to large towns in Yorkshire and Lancashire.

ROCK WATERS.

ORDER OF ROCKS, &c.—continued.

Period.	Group.	Sub-divisions.	Waters.
PALÆOZOIC OR PRIMAR Y.	Carboniferous	Carboniferous or Mountain Limestone.	The black limestone gives a water of an earthy and sulphurous taste, due to the presence of organic matter. The lighter limestones yield water organically pure, and of moderate temporary hardness (p. 217). The water is plentiful from fissures, but may then be mixed with much unfiltered surface water. In Mendip and Derbyshire rivers often disappear in "swallow holes." There is a regular business of stopping up these holes to prevent loss of water in dry seasons (Hughes). Mineral veins of lead and zinc sometimes contaminate the water, which always needs a chemical examination.
Devonian or Old Red Sandstone.	Quartzose Conglomerate. Cornstone (clays and marls).		Waters usually good, but scarce. There are no wells for large supply, but where clay beds occur there is abundance at no great depth for private houses. Sometimes bituminous schists occur, containing remains of fishes; these give undrinkable water.
Upper Silurian.	Tilestone (sandy). Ludlow Shales. Wenlock Limestone.		Tilestone water is good. The shales and limestones often give very inferior turbid and hard waters.
Lower or Cambro-Silurian. Laurentian ..	Caradoc Sandstone. Llandeilo Flags. (Chiefly in Canada).		Usually very soft and pure waters of granitic character. Like granitic waters, but of greater hardness, owing to the presence of crystalline limestones.

ORDER OF ROCKS, &c.—continued.

Period.	Group.	Sub-divisions.	Waters.
IGNEOUS and METAMORPHIC. (May be of any age, but more common in the primary.)	(Mineral veins are frequent, and may cause metallic contamination of the waters with iron, lead, zinc, or copper, and also acidity.)	Granite, Gneiss, Quartz Rock, Mica Schist, Slate.	Very soft waters, containing potass, salts and silica, but little lime or magnesia. Usually bright and clear, and slightly alkaline. From very rapid streams there may be a white turbidity. Organically of great purity. Slaty waters often contain iron from decomposing pyrites, and are acid, and of a bad taste and earthy odour.

Crystalline	Limestone	Hard, from bicarbonate of lime, otherwise pure.
Volcanic Ash	or	Vary, often acid, alkaline, or ferruginous from decomposing minerals. Organically pure.
Tufa. Trachyte.	Trap and Basalt	Alkaline and silicious, or may be acid or sulphuretted from presence of sulphur. Springs from volcanic rocks are frequently medicinal, but seldom potable. The temperature is usually high.

Serpentine	..	When decomposed may give magnesian waters.
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