THE RIVER NILE.

By H. Droop Richmond, Late Second Chemist to the Egyptian Government.

I. INTRODUCTION.

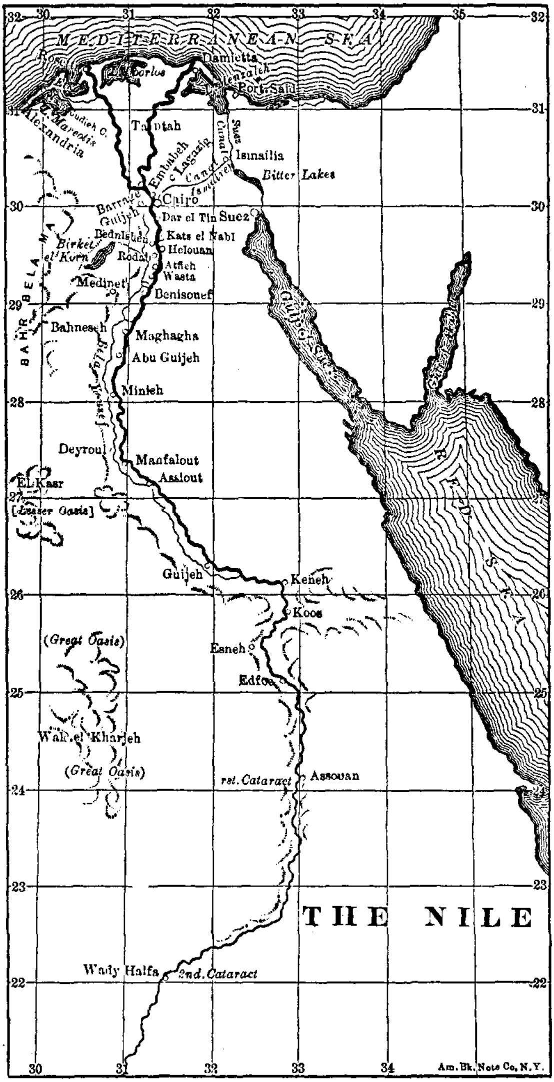
The river Nile, the water-way of Egypt, is chiefly fed by the great equatorial rains; it drains an enormous area of northeast and northeast-central Africa, and reaches from about 4° south latitude to 31° north latitude, and runs, broadly speaking, south to north.

The Nile proper does not exist before Khartoum is reached; south of this it is composed of (a) the White Nile, (b) the Blue Nile, into which runs just above Berber the (c) Atbara or Black Nile. • These names do not indicate the color of the water, but rather the intensity of the color due to suspended matter, and afford an instance of the figurativeness of Oriental language.

(a) The White Nile has its sources in the three great lakes, the Victoria, Albert, and Albert Edward Nyanzas, and receives the waters chiefly from the northern and eastern sides of the snow-clad mountains by means of many small tributaries; it passes for some distance after leaving the lakes through a marshy country, and here takes up a considerable quantity of vegetable matter, to which the green color noticed just before the flood is due; some of its tributaries, notably the Saubat, contain carbonate of calcium in suspension, and to this its name of White Nile has been ascribed by many, though it owes its name more to its comparative cleanness and freedom from suspended matter.

(b) The Blue Nile drains the southern side, (c) the Atbara the northern side, of the Abyssinian mountains; they are both of the same character, and contain large quantities of mud in suspension, especially in flood time, and to this, which imparts a dark red-brown color to the water, are the names Blue and Black Nile due.

All three rivers rise in the spring, the White Nile to a less extent than the others; except during this rise the water of the Blue Nile is small in amount compared with that in the White, which has large reservoirs in the lakes; this comparative constancy of the White Nile prevents the Nile in Egypt from sinking into insignificance. The rise of the White Nile always takes place before that of the Blue, and the first symptom of this is the carrying down of its more or less stagnant waters of a greenish hue, which reach Cairo about the months of June or July, and cause the Nile water to be at its worst at that period; about a month afterwards the Blue Nile rises enormously and carries down with it immense quantities of suspended mud, and it is to this rise that the flood of the Egyptian Nile is due.



The two rivers join at Khartoum, and run for miles side by side with a fairly sharp line of demarcation, distinguished by the difference of color of the two waters; it flows thence over four "cataracts" or rather rocky parts to Wady

Halfa, where it enters Egypt, and at which point the present research commenced; near Wady Halfa is the second and largest cataract, and from then it continues to the first cataract at Assouan, where is a Nilometer or *gauge* of the height of the river. from the readings of which the state of the flood is *gauged*; flowing past Edfoo, where is another Nilometer, (now disused, but of great interest as having furnished the clue to the length of the Nile "pic" or "drâa," the measure of the ancient Egyptians; c. f. Moukhtar Pasha, *Etudes sur les Mesures Egyptiennes*, Cairo, 1890), and Keneh, it reaches Assiout, where the Ibrahimieh canal leaves the river, to become at Deyrout the Bahr Yousef, or Yousefy River, which waters the Fayoum, and ends in the Birket-el-Kûm, often called Lake Moeris, but probably not the lost Lake Moeris, which was farther south. From Assiout, it flows past Minieh and Beni-Souef to Cairo, where on the southern end of the Island of Rodah is another Nilometer, anciently used to show the state of the flood, but whose indications are now too much affected by the drawing off of water in Upper Egypt for irrigation purposes to be reliable. At Cairo the Ismailieh Canal branches off to Ismailia and falls into the Gulf of Suez near the town of Suez. Nineteen miles beyond Cairo is the Barrage, a great bridge whose arches can be closed, converting it into a dam and raising the water level so that the irrigation canals can be supplied. At the Barrage it divides into the Damietta branch, which empties into the Mediterranean at Damietta, and the Rosetta branch, dividing into the Mahmoudieh canal, which has its exit at Alexandria, and the Raschidieh canal, which discharges at Rosetta; a fifth branch anciently flowed through Lake Menzaleh. From these branches the Delta is supplied by numerous smaller canals. Along the north coast are Lakes Mareotis (filled by the British from the sea at the commencement of the century), Edko, Bourlos, etc., which are highly charged with sodium chloride; waters of this description occur also at Shaloof and other places near the Suez Canal (c. f. Richmond and Opp, *J. Soc. Chem. Ind.*, **9**, 1108, and Richmond, *Analyst*, **17**, 163); the water from these lakes finds its way into the lower branches of the Nile and somewhat alters its character. The waters of the Bahr Yousef are also affected in a similar manner.

II. THE NILE CHEMICALLY CONSIDERED AS THE WATER SUPPLY OF EGYPT.

The first chemical study was made in 1874-5 by the late Dr. Letheby; he analyzed twelve monthly samples of the water taken at Boulak, sent to him by the Public Works Department; an extract of his analyses is given in Table I; he also made a mineral analysis of each sample.

TABLE I. ANALYSES BY DR. LETHEBY IN 1874-75.

Date.	Height of Nile.	Total solids.	Suspended matter.	Chlorine.	Free ammonia.	Albuminoid ammonia.	Nitric acid.	Oxygen absorbed.	Coefficient of purity.
Jan. 23, 1875	15.00	14.47	16.74	0.24	0.0087	0.0143	Trace	0.257	67.4
Feb. 12, 1875..............	14.71	14.67	12.57	0.25	0.0048	0.0166	"	0.317	81.0
Mar. 15, 1875	14.26	17.81	5.31	0.61	0.0036	0.0086	"	0.417	92.7
Apr. 15, 1875	13.24	18.19	6.63	0.92	0.0035	0.0107	"	0.517	104.8
May 13, 1875..............	13.02	20.47	4.77	1.74	0.0014	0.0118	"	0.625	137.1
June 8, 1874	12.59	20.30	6.91	1.64	0.0057	0.0114	"	0.300	72.5
July 10, 1874	13.76	16.39	17.84	0.85	0.0129	0.0100	"	0.211	54.8
Aug. 12, 1874	20.18	16.60	149.16	0.63	0 0043	0.0071	"	0.237	55.4
Sept. 20, 1874	22.32	19.44	54.26	0.21	0.0100	0.0171	"	0.386	96.3
Oct. 12, 1874	22.83	15.86	37.80	0.49	0.0071	0.0143	"	0.483	112.3
Nov. 12, 1874..............	18.31	14.91	34.37	0.21	0.0064	0.0114	"	0.269	76.5
Dec. 12, 1874	16.28	13.61	28.91	0.28	0.0049	0.0108	"	0.186	49.0

In his report to the Public Works Department he drew attention to the variable character of the water, and to the amount of organic matter, and albuminoid ammonia, *which were largely in excess of those in the rivers of Europe.* This last statement laid the foundation for the general opinion that the Nile water is bad, an opinion contrary to that arrived at by the French Expedition at the begining of the century, who did not, however, make chemical examinations. Wanklyn also examined samples at the same time, and drew attention chiefly to the variation in the chlorine.

The Egyptian chemists Tanquerel 1883, (*Annuaire Egyptienne*, 1891), Pappel, 1886, and Pollard, 1888-9, (*Report of the Sanitary Administration*, 1889) also studied the Nile. Tanquerel did little more than study the mineral constituents; Pappel made twelve monthly analyses (omitting however the determination of suspended matter), but his results are so full of obvious discordances, possibly clerical errors, which a personal reference to this chemist has failed to explain, that they must be rejected as useless; Pollard made twenty-four bi-monthly analyses of considerable value, which are given in Table II.

TABLE II. ANALYSES BY MR. POLLARD IN 1888–89.

Date.	Height of Nile.	Total solids.	Suspended matter.	Chlorine.	Free ammonia.	Albuminoid ammonia.	Nitric acid.	Oxygen absorbed.	Coefficient of purity.
Jan. 5, 1889	14.03	13.2	13.6	0.36	...	0.010	0.10	0.32	74.5
" 19, 1889	13.93	14.0	12.8	0.50	0.002	0.010	0.13	0.33	77.0
Feb. 2, 1889	13.69	15.7	10.2	0.71	...	0.009	0.05	0.295	68.2
" 16, 1889	13.52	17.3	8.7	1.14	0.001	0.010	0.04	0.28	66.4
Mar. 2, 1889	13.47	19.5	6.0	0.14	...	0.010	0.04	0.28	66.2
" 16, 1889	13.40	20.2	5.0	1.79	0.001	0.011	0.07	0.32	75.3
Apr. 6, 1889	13.36	23.0	5.9	2.21	...	0.012	0.06	0.20	79.3
" 20, 1889	13.33	25.8	4.0	2.64	...	0.011	0.05	0.27	65.2
May 4, 1889	13.31	26.35	3.2	3.00	0.001	0.011	0.06	0.28	67.5
" 18, 1889	13.33	29.0	1.7	3.43	0.001	0.011	0.08	0.29	69.6
June 8, 1888	13.33	28.3	3.3	4.00	0.002	0.012	0.11	0.27	66.0
" 23, 1888	13.79	23.7	2.77	3.14	0.020	0.037	0.16	0.41	123.8
July 7, 1888	13.36	29.2	1.4	3.00	...	0.020	0.02	0.30	80.1
" 21, 1888	14.14	23.4	6.0	1.93	0.003	0.020	0.03	0.22	64.7
Aug. 4, 1888	14.30	20.3	...	1.50	0.008	0.017	0.03	0.28	74.7
" 20, 1888	17.43	14.3	163.1	0.57	0.005	0.007	0.38	0.30	60.9
Sept. 1, 1888	18.64	13.7	231.2	0.36	0.007	0.010	0.32	0.32	77.0
" 22, 1888	18.55	12.8	163.6	0.29	0.004	0.011	0.19	0.23	58.8
Oct. 6, 1888	17.38	12.2	105.6	0.29	0.003	0.012	0.19	0.275	55.6
" 20, 1888	16.42	12.5	...	0.26	0.001	0.010	0.22	0.22	55.3
Nov. 3, 1888	16.44	13.7	81.3	0.24	...	0.070	0.19	0.25	71.0
" 17, 1888	14.98	12.4	48.3	0.36	0.001	0.007	0.22	0.29	66.3
Dec. 8, 1888	14.39	12.6	26.2	0.29	0.001	0.006	0.17	0.22	51.1
" 22, 1888	14.19	13.6	20.9	0.29	...	0.008	0.11	0.28	64.5

Sundry French chemists have made from time to time analyses too isolated to have any value in the study of a constantly changing river like the Nile.

The whole of the foregoing analyses were made on water taken from the river at Cairo, and no attempt was made to study it at other points.

As already stated the Nile water enjoys a somewhat bad reputation, due in the first instance to Letheby, and greatly enhanced by Pappel, and to some extent Pollard; the grounds for Letheby's opinion have already been stated; Pappel's analyses are unreliable, and therefore his opinion cannot be held to have great weight, though from his position of Chief Government Chemist it was received with authority in Egypt; the latter and Pollard based their opinion on the fact that in the Nile the limits 0.004 parts per hundred thousand of albuminoid ammonia, and 0.2 parts per hundred thousand of oxygen absorbed in the Forehammer process were exceeded. As the Nile is (chemically) almost unknown, the judging of the water by these arbitrary standards is not entirely defensible; the chemical evidence therefore that the Nile, which has been drunk by generations during six thousand years, is bad for potable purposes, is weak.

At the beginning of 1891 His Excellency, Dr. Greene Pasha, Director of the Sanitary Administration, thought it desirable to examine the water of the Nile as near its source as was possible, and he entrusted the work to my hands; with him I sketched the following plan to include analyses of (a) the Upper Nile at Wady Halfa, Assouan, Keneh, Assiout, Minieh, and Cairo; (b) the Lower Nile at Cairo, Alexandria on the Mahmoudieh canal, Rosetta on the Raschidieh canal, Damietta on the Damietta branch, Ismailia, Port Said and Suez on the Ismailieh canal, and Tantah and Zagazig on two branch canals; (c) the Bahr Yousef, at Assiout, Deyrout, and Medinet-el-Fayoum; (d) at Cairo, to study specially the monthly variations and the water of the Cairo Water Company.

The machinery of the Sanitary Administration was placed at my disposal by His Excellency, Greene Pasha, and through the kindness of Colonel Ross, Chief Inspector of Irrigation, and His Excellency, Rogers Pasha, Principal Medical Officer of the Egyptian Army, I was also able to avail myself of the aid of the Public Works and War Departments. I take this opportunity of expressing my thanks to these gentlemen and also to His Excellency, Mahmoud Pasha Sidky, Sub-Director of the Sanitary Administration, to Mohammed Bey Sidky, Chief (pro tem.) of the Technical Service Public Works Department, and to the various officials of the three departments who aided me.

All samples, except at Cairo, were taken in mid-stream by plunging a bottle to a distance of half a meter below the surface and there, after rinsing, filling it; the samples at Cairo were taken at the Kasr-el-Nil bridge by myself with the apparatus described hereafter; the water was forwarded with the least possible delay to the Khedivial Laboratory at Cairo, and the analysis immediately commenced.

The analyses are given in Tables III (Cairo), IV (Wady Halfa, Assouan, Keneh, Minieh, and Cairo), V (Alexandria, Rosetta, Damietta, Tantah, and Zagazig), VI (the same and

Cairo), VII (Ismailia, Port Said, Suez, and Cairo), VIII (Assiout, Deyrout, and Medinet-el-Fayoum), IX (Rodah, Kasr-el-Nil, and Embabeh, all near Cairo), and X (showing the effect of filtration through various media). All results are stated in parts per hundred thousand, and were obtained from the water twice filtered through paper to remove suspended matter; this proceeding has some objections, shown in Table X, but as it had been adopted by my predecessors I continued it; all results are, however, comparable (with exceptions mentioned hereafter).

TABLE III. ANALYSES AT CAIRO DURING 1891.

Date.	Height of Nile.	Total solids.	Suspended matter.	Chlorine.	Free ammonia.	Albuminoid ammonia.	Nitric acid.	O absorbed, 15 minutes.	O absorbed, 4 hours.	Coefficient of purity.
Mar. 25, 1891	13.82	17.96	3.84	1.01	0.001	0.025	Trace	0.081	0.186	60.0
Apr. 28, 1891	13.98	23.12	4.52	2.09	0.007	0.038	"	0.063	0.160	68.0
May 26, 1891	13.82	19.64	1.44	2.91	0.003	0.019	"	0.124	0.264	70.8
June 29, 1891	14.23	15.84	6.60	1.41	0.002	0.043	"	0.166	0.289	105.5
July 25, 1891	14.48	17.16	31.32	0.64	Trace	0.016	0.03	0.089	0.145	48.2
Aug. 28, 1891	18.71	16.20	188.64	0.66	0.002	0.012	0.01	0.084	0.137	42.9
Sept. 31, 1891	19.13	13.12	160.44	0.56	0.002	0.008	Trace	0.074	0.124	35.6

TABLE IV. ANALYSES AT CAIRO (CA.), MINIEH (MI.), ASSIOUT (AT.), KENEH (KE.), ASSOUAN (AN.), AND WADY HALFA (W. H.).

Date.	Place.	Total solids.	Chlorine.	Free ammonia.	Albuminoid ammonia.	Nitric acid.	O absorbed, 15 minutes.	O absorbed, 4 hours.	Coefficient of purity.	Coefficient of P. corrected.
May	Ca.	19.64	2.91	0.003	0.019	Trace	0.124	0.264	70.8	70.8
"	Mi.	99.56	39.50	0.004	0.015	2.1	0.119	0.212	...	...
"	At.	19.96	2.45	0.012	0.039	0.09	0.148	0.267	98.1	98.1
"	Ke.	21.08	2.00	0.004	0.028	0.08	0.138	0.257	82.5	115.5
"	An.	...	...	...	...	...	...	...	...	...
"	W. H.	18.96	1.82	0.001	0.014	Trace	0.063	0.114	38.2	76.4
June	Ca.	15.84	1.41	0.002	0.043	"	0.166	0.289	105.5	105.5
"	Mi.	18.24	1.36	0.006	0.034	0.18	0.097	0.163	71.8	...
"	At.	14.60	1.32	0.073	0.059	None	0.164	0.372	143.6	143.6
"	Ke.	14.24	1.14	0.116	0.043	"	0.121	0.248	115.2	161.3
"	An.	14.64	1.09	0.134	0.031	"	0.104	0.208	99.4	161.0
"	W. H.	...	...	...	...	...	...	...	...	...
July	Ca.	17.16	0.64	Trace	0.016	0.03	0.089	0.145	48.4	48.4
"	Mi.	18.32	0.86	0.011	0.015	0.25	0.091	0.172	53.8	...
"	At.	16.36	0.68	Trace	0.010	0.02	0.089	0.145	42.4	42.4
"	Ke.	15.44	0.64	"	0.017	0.02	0.103	0.187	56.4	79.0
"	An.	13.84	0.59	"	0.010	Trace	0.094	0.154	43.8	70.1
"	W. H.	13.20	0.44	"	0.013	"	0.090	0.181	49.1	98.2
August	Ca.	16.20	0.66	0.002	0.012	0.01	0.084	0.137	42.9	42.9
"	Mi.	...	...	...	...	...	...	...	...	...
"	At.	13.60	0.51	0.005	0.024	Trace	0.075	0.198	60.8	60.8
"	Ke.	...	...	...	...	...	...	...	...	...
"	An.	13.20	0.44	Trace	0.013	Trace	0.057	0.139	38.3	61.3
"	W. H.	11.68	0.32	0.001	0.009	"	0.075	0.159	40.1	80.2

TABLE V. ANALYSES AT ALEXANDRIA, ROSETTA, DAMIETTA, TANTAH, AND ZAGAZIG.

Date.	Place.	Total solids.	Chlorine.	Free ammonia.	Albuminoid ammonia.	Nitric acid.	O absorbed, 15 minutes.	O absorbed, 4 hours.	Coefficient of purity.
May 17, 1891.	Alexandria.	24.60	2.91	0.004	0.026	0.02	0.112	0.258	75.1
June 19, 1891.	"	24.36	2.68	0.001	0.024	Trace	0.096	0.175	60.9
July 16, 1891.	"	21.04	1.73	0.002	0.018	"	0.072	0.186	46.1
May 20, 1891.	Rosetta.	20.48	2.00	0.012	0.028	0.04	0.128	0.257	81.9
Aug. 20, 1891.	"	...	...	0.001	0.015	Trace	0.062	0.132	40.8
May 15, 1891.	Damietta.	30.36	5.18	0.020	0.040	0.07	0.095	0.161	49.1
June 20, 1891.	"	46.76	11.36	0.006	0.023	Trace	0.069	0.139	36.1
July 16, 1891.	"	30.86	12.86	0.002	0.010	0.09	0.080	0.152	47.4
Aug. 16, 1891.	"	137.68	69.1	0.009	0.014	None	0.112	0.271	73.3
May 24, 1891.	Tantah.	22.73	2.77	0.009	0.022	"	0.112	0.271	73.3
July 12, 1891.	"	17.32	1.23	0.001	0.013	0.06	0.067	0.137	40.6
June 10, 1891.	Zagazig.	23.96	2.64	0.010	0.013	Trace	0.064	0.109	38.7
July 14, 1891.	"	17.84	1.14	0.001	0.020	0.05	0.065	0.133	46.7
Aug. 10, 1891.	"	16.88	0.87	0.001	0.010	0.02	0.062	0.134	36.1

TABLE VI. AVERAGES OF TABLE V.
(Differences in total solids, corrected for chlorine.)

Place.	Total solids.	Chlorine.	Coefficient of purity.
Cairo	18.94	1.51	73.1
Alexandria	23.33	2.44	60.8
Difference	+2.84	+0.93	—12.3
Cairo	18.39	1.34	67.1
Damietta	63.90	24.62	58.9
Difference	+6.71	+23.28	—8.2
Cairo	18.39	1.34	67.1
Tantah	20.02	2.00	55.9
Difference	+0.53	+0.66	—12.2
Cairo	17.21	1.65	60.8
Zagazig	19.55	1.55	40.5
Difference	+2.50	—0.10	—20.3

TABLE VII. ANALYSES AT CAIRO, ISMAILIA, PORT SAID, AND SUEZ.

Date.	Place.	Total solids.	Chlorine.	Free ammonia.	Albuminoid ammonia.	Nitric acid.	O absorbed, 15 minutes.	O absorbed, 4 hours.	Coefficient of purity.
April-May	Cairo.	23.12	2.09	0.007	0.038	Trace	0.063	0.160	68.0
" "	Ismailia.	25.50	2.82	0.009	0.024	0.05	0.121	0.274	77.5
May-June	Cairo.	19.64	2.91	0.003	0.019	Trace	0.124	0.264	70.8
" "	Ismailia.	19.96	2.77	0.002	0.024	0.18	0.999	0.236	68.7
" "	Suez.	24.60	3.86	0.003	0.019	Trace	0.098	0.236	62.8
" "	Port Said.	22.82	2.86	Trace	0.013	"	0.054	0.137	37.5
June-July	Cairo.	15.84	1.41	0.002	0.043	"	0.166	0.289	105.5
" "	Ismailia.	16.56	1.36	0.004	0.029	0.04	0.108	0.204	72.0
" "	Suez.	27.00	4.07	0.001	0.022	Trace	0.091	0.174	57.8
" "	Port Said.	20.52	2.27	0.001	0.013	"	0.053	0.106	34.4
July-August ...	Cairo.	17.16	0.64	Trace	0.016	0.03	0.089	0.145	45.2
" " ...	Ismailia.	16.08	0.67	0.003	0.021	0.07	0.079	0.145	52.2
" " ...	Suez.	22.36	3.03	0.001	0.017	Trace	0.091	0.168	52.2
" " ...	Port Said.	16.84	1.01	Trace	0.012	"	0.065	0.124	37.4

TABLE VIII. ANALYSES AT ASSIOUT, DEYROUT, AND MEDINET-EL-FAYOUM.

Date.	Place.	Total solids.	Chlorine.	Free ammonia.	Albuminoid ammonia.	Nitric acid.	O absorbed, 15 minutes.	O absorbed, 4 hours.	Coefficient of purity.
May	Assiout.	19.96	2.45	0.012	0.039	0.09	0.148	0.267	98.1
"	Deyrout.	17.40	...	0.006	0.027	0.04	0.114	0.250	76.2
"	Fayoum.	47.32	11.73	0.007	0.037	0.01	0.110	0.226	70.0
June...........	Assiout.	14.60	1.32	0.073	0.059	None	0.164	0.372	143.6
"	Deyrout.	15.28	1.26	0.001	0.038	0.17	0.111	0.214	82.6
"	Fayoum.	49.28	13.00	0.002	0.025	Trace	0.080	0.135	55.9
July	Assiout.	16.36	0.68	Trace	0.010	0.02	0.089	0.145	42.4
"	Deyrout.	17.00	0.82	0.008	0.023	0.26	0.079	0.160	57.7
"	Fayoum.	27.56	4.48	0.001	0.037	0.03	0.119	0.248	85.9

Mean coefficient of purity:

Assiout 93.7
Deyrout 72.2
Fayoum 70.3

TABLE IX. ANALYSES AT RODAH, KASR-EL-NIL, AND AFTER KEEPING.

Place.	Total solids.	Chlorine.	Free ammonia.	Albuminoid ammonia.	Nitric acid.	O absorbed, 15 minutes.	O absorbed. 4 hours.	Coefficient of purity.
Rodah	20.08	2.82	0.002	0.019	0.01	0.112	0.256	67.4
Kasr-el-Nil.............	19.64	2.91	0.003	0.019	Trace	0.124	0.264	70.8
Embabeh	19.72	2.82	0.004	0.018	0.01	0.129	0.275	72.1
Embabeh after 6 weeks	...	...	0.002	0.013	0.13	0.051	0.108	34.9

TABLE X. SHOWING THE EFFECT OF FILTRATION THROUGH VARIOUS MEDIA.

Designation.	Ammonia. Free.	Ammonia. Albuminoid.	Nitric acid.	O absorbed. 15 min.	O absorbed. 4 hrs.	Coefficient of purity.
a..........	0.010	0.021	Trace	0.127	0.200	68.4
b..........	Trace	0.016	0.03	0.089	0.145	48.4
c..........	Trace	0.009	0.13	0.057	0.080	29.0
d..........	0.014	0.005	None	0.017	0.030	14.2

[TO BE CONTINUED.]