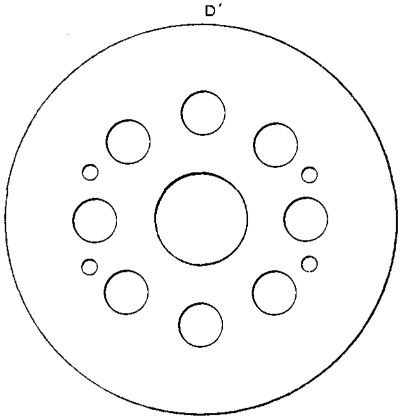
inches. The temperature at which the drying is to be made can be fixed at any desired point, from low temperatures up to as high as can be safely used without charring the material to be desiccated. For ordinary work the lamp is set for a temperature of 100°.

From six to eight of these drying flasks are connected *en batterie* with the pump. Each one can be connected or disconnected with the pump by its stop cock, G. If a current of hydrogen is to be introduced into the drying flask it is easily accomplished by passing a very small glass tube through the cork, joined to another tube by a rubber connection immediately below the cork. The inner tube should pass nearly to the bottom of the flask and be weighed with it. The hydrogen is sucked into the flask, passing through a wash bottle containing caustic soda and then sulphuric acid and over solid potash. The speed of the current, which need not be very great, is controlled by a stop or pinch cock. Any of the sample which may touch the inner tube during the intumescence caused by desiccation remains thereon and is weighed at the end with the tube which is detached and left in the drying bulb.

D′



THE RIVER NILE.

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

Continued from p. 42.

IN order to more readily compare the different analyses, I adopted a modification of Wigner's scale (*Analyst*, **IV.** c. f. Muter, *Analyst* **8,** 93). I do not agree with Wigner that a scale can be constructed for all waters, but I am of opinion that in a case like this, when a number of waters of the same origin have to be compared, that it is of use, though not of rigid exactitude. I wish to state distinctly that my scale is for the water of the Nile *only* after double filtration through paper (and in a few other occasional cases).

In drawing up my scale and limits I took into account the origin of the impurities in the Nile, its rapid self-purification, the absence of nitrates, and other small points; the task of giving all the reasons in detail would be too difficult and lengthy to permit their publication in a paper of this kind, and I give the scale adopted without further comment.

Each 0.005	parts of	free ammonia	= 1
" 0.001	"	albuminoid ammonia	= 1
" 0.005	"	oxygen absorbed in fifteen minutes	= 1
" 0.01	"	" " " four hours	= 1
" 0.2	"	nitric acid	= 1

For Letheby's and Pollard's analyses

Each 0.005 parts of oxygen absorbed = 1

The limits I propose, are:

Good water up to about 50.
Moderate water from about 50 to about 100.
Bad water over about 100.

This value I term "coefficient of purity."

In the case of waters from Wady Halfa, Assouan, and Keneh, the time of transit was longer than is desirable, and I have corrected their coefficient of purity by adding 100 per cent. to the Wady Halfa analyses, sixty per cent. to the Assouan analyses, and forty per cent. to the Keneh analyses. The figures are based on my experiments on the self-purification of the water, and give rough approximations. I have thought it more useful to employ these approximations than to reject the analyses altogether, but they can only be regarded as giving general indications.

I have had to reject the Minieh results for reasons stated below. In order to compare the results in Table V their averages are given in Table VI; the Bahr Yousef results in Table VIII are also averaged.

The methods of the Society of Public Analysts were adopted with the following modifications:

(1) The total solids were dried at 150° C.

(2) The nitric acid was determined by the copper-zinc couple

(Williams, *J. Chem. Soc.*, 1881, 100), nine-tenths of the free ammonia being subtracted, and the remaining ammonia multiplied by 3.2 to give the quantity of nitric acid; these constants were experimentally determined for the Nile water.

(3) The suspended matter was determined by evaporating a known quantity of unfiltered water, drying at 150°, and subtracting the total solids of the filtered water.

An inspection of the tables and diagrams leads to the following conclusions:

(a) The total solids and chlorine increase regularly during the flow of the river.

(b) The coefficient of purity decreases regularly, showing a continual purification.

(c) The nitric acid is very small.

(d) The Nile in its passage through Cairo undergoes slight but distinct pollution.

(e) The Nile water on standing purifies itself (this has been otherwise confirmed).

Conclusion (a) is especially brought out by the results on the Bahr Yousef and the Lower Nile, where the current is less rapid than on the Upper Nile.

(f) Filtration purifies the water of the Nile. This will be more fully discussed under part III.

The results at Rosetta have been rejected on account of the small number of analyses, and those of Minieh because there is evidence of the samples not having been taken in accordance with directions; the Nile at Minieh is very wide (one and a half miles) and near the town the water is very shallow and has practically no current, and it is more than probable that the samples were taken at a short distance from the bank instead of in mid-stream. The occurrence of nitric acid at some parts and its disappearance at others caused at first some surprise, but this is probably due to the fact that the bed of the Upper Nile contains iron in the forms of ferrous and ferric silicates and magnetic oxid in considerable quantities, pointed out by Johnson Pasha and myself in a communication to the Geological Society. The absence of nitric acid at Port Said is due to the fact that the water is conveyed many miles in iron pipes; a similar disappearance of nitrates from a like cause is recorded by Harvey (*Analyst*, **14**, 34); the suspended matter in the Nile is highly ferruginous and this plays its part, doubtless, in the disappearance of nitrates and the purification of the water. The action of iron and its compounds in purifying waters is not understood, and deserves further study.

(*g*) The Nile is at its worst just before the flood, and at its best just afterwards. There is a second small rise in the coefficient of purity about the time when the flow of the Nile is checked by the opening of the irrigation canals and basins. (This will be further discussed in Part III.)

(*h*) The total solids and chlorine vary in inverse ratio to the height of the Nile, or in other words to its bulk.

This is almost a foregone conclusion, as it is evident that a larger bulk moving at a quicker rate will not take up so large a percentage of impurity as a less quantity.

III. THE CAIRO WATER COMPANY. NOTES ON THE WATER SUPPLY AND SANITATION OF EGYPT.

The Cairo Water Company draws its supply from the Nile just below the Kasr-el-Nil Barracks; the water is pumped to the filter beds at Abbasiyah, about three and a half miles; it flows first into a tank where a proportion of the suspended matter settles, and thence to the filter beds, which are composed of sand, fine, medium, and coarse gravel, and small stones, in layers of about thirty cm. each, the total thickness being 1.75 meters, and the filtered water is received in two covered reservoirs; from these it descends by gravitation to Cairo, about two miles off.

The company has a concession from the government expiring in 1913 for the sole supply of water, both filtered and unfiltered, to Cairo; the water is not required to be of any special purity, as long as it is *not worse than the Nile water*.

From time to time the *Bosphore Egyptien*, a Cairo journal, has complained of the quality of the water, and occasionally the government has ordered chemical investigations. The most important of these was carried out by Pappel and *Legros* in 1887, and in their report they condemned the water as bad, and recommended very radical changes in the beds of the company, including the construction of a tunnel of considerable length filled with broken bricks, the increasing of the thickness of the filtering layer to 3.75 meters, and the building of a high wall to enclose the filter beds; they considered a settling tank not only useless, but rather injurious; no experiments were made beyond some half dozen determinations of free and albuminoid ammonia in the water and the sand of the filter beds. This report was criticised very unfavorably by Tanquerel, of Cairo, and Muntz, of Paris, and the company brought forward certain facts in their defence which led the government to drop all inquiry.

By reason of the false position in which the government was placed, it was unable to get the water company to make any improvements, and the company became skeptical concerning scientific recommendations. In 1890 an outcry against the water was again raised, and the government took the matter up and entrusted the work to my hands.

I made analyses as follows:

	Water at intake.	Water in reservoir I.	Water in reservoir II.
Total solids	14.56	14.32	14.44
Loss on ignition	1.52	1.08	1.20
Oxygen absorbed, 4 hours	0.268	0.140	0.177
Free ammonia	0.016	0.011	0.023
Albuminoid ammonia	0.039	0.009	0.011

As there was evidence of considerable purification, I reported to that effect, and refrained from offering unasked-for suggestions.

The attitude of the company became more favorable, and I believe they are quite willing to adopt any reasonable suggestions for the more efficient purification of the water. I am indebted to the kindness of the Director of the Cairo Water Company for aid in this research by the supply of sand for filtration.

TABLE XI. ANALYSES OF THE CAIRO WATER COMPANY'S WATER.

Date.	Total solids.	Suspended matter.	Chlorine.	Free Ammonia.	Albuminoid ammonia.	Nitric acid.	O absorbed, 15 minutes.	O absorbed, 4 hours.	Coefficient of purity.	Coef. of P. ÷ Coef. of P. of Nile water.
Mar. 25, 1891	17.72	Trace	1.03	0.001	0.008	0.03	0.051	0.103	34.0	0.57
Apr. 23, 1891	24.70	None	2.21	0.004	0.007	0.01	0.048	0.119	29.3	0.43
May 26, 1891	20.76	"	3.14	0.001	0.009	0.08	0.064	0.189	41.3	0.58
June 29, 1891	18.80	"	1.43	0.001	0.024	0.01	0.069	0.149	52.9	0.50
July 28, 1891	18.60	Trace	0.91	Trace	0.009	0.13	0.057	0.080	29.0	0.60
Aug. 28, 1891	17.24	"	1.02	0.001	0.007	0.05	0.053	0.082	26.2	0.61
Sept. 31, 1891	14.12	"	0.79	0.001	0.005	0.08	0.045	0.092	23.8	0.67

In Table XI are given the results of the analyses of the water of the company made contemporaneously with those of the Nile at Cairo.

It is seen that the total solids and the chlorine remain almost the same as the quantities found in the Nile, the slight increase in the chlorine being due to the presence of small quantities of salt in the sand; the coefficient of purity is, however, in all cases diminished about fifty per cent. The filters of the Cairo Water Company then do their work properly, and result in a purification of the Nile water. Judged by my scale, the water may be, except perhaps in June, considered good.

As the word "good" in water analysis is used somewhat loosely, and does not mean perfect, I instituted experiments in order to find out a better means of purifying the Nile water; it is not necessary to detail the experiments, and I only give (in Table X) the figures of one of them. Four samples of the same water were examined.

(*a*) After precipitation of the suspended matter by a very small quantity of ferric chloride.

(*b*) After filtration as usual through double filters.

(*c*) After filtration through a layer of sand the same thickness as used by the Cairo Water Company.

(*d*) After filtration through a layer of fine sand 0.75 meter thick, a layer of "polarite" 0.20 meter thick, and a layer of coarse sand 0.75 meter thick.

From the results it is seen that filtration, even through paper (and its own suspended matter), improves the Nile water, doubtless assisted by the large surface exposed to the air; filtration through sand improves it still more, and after filtration through "polarite" very little fault can be found with the water. The "polarite" in this case has exercised a reducing influence on the nitrates; this is not always the case, and seems to take place when the "polarite" is fresh. In all my experiments the "polarite" purified the water to the extent of about eighty per cent., judged by my scale; as to the exactness of this figure I cannot vouch, but it is certain that no other filtering material has given such satisfactory results in my hands. I therefore can strongly recommend the use of "polarite" to the Cairo Water Company. I may mention that this material was handed to me with the simple description of "material for purifying water" and it was only after some difficulty that I established its identity. The monthly variations of the water of the company follow those of the Nile; the quality of the water in the river is dependent on the following:

(a) The (presumable) purity in the water of the Nyanzas and of the rainfall collected by the great watersheds of the White, the Blue, and the Black, Nile; (b) the taking up of impurities in the marshy districts of Central Africa; (c) the taking up of impurities during its flow, and the pollution of the river established at Cairo and more than probable at other points; (d) the self-purification of the river, in which the minerals in its bed and the suspended matter, probably aid the oxygen of the air. The quality of the Company's water is also dependent on (e) the filtering materials used.

The water at Port Said (*q. v.*) is analogous to the Cairo Water Company's water, as it is filtered at Ismailia before traversing the iron pipes which convey it to Port Said. The absence of nitrates at Port Said has already been explained.

My recommendation to the Cairo Water Company may profitably be extended to the other towns of Egypt; the Alexandria Water Company adopts a modification of Anderson's process, the short canal conveying the water from the Mahmoudieh Canal to their works being partly filled with scrap iron; my experiments showed me, however, that this method of purification was not so efficient as that by "polarite."

On looking over the results of the analysis of the water of the Bahr-Yousef, it has struck me that the apparent exception in July (see Table VII) may seem to contradict the conclusion I have drawn that the water of the Nile purifies itself during its flow; a glance at the conditions of the Bahr Yousef will make it plain that this is but an apparent exception. In June the Nile is at its worst; it is directly afterwards flushed by the flood; as the Bahr-Yousef empties itself into the Birket-el-Kûm, which has no apparent outlet, a rapid flow of water cannot take place; the effect of the flood is to push down gradually the water that is in it. We should expect then to find the June bad water to occur at a later date in the Bahr Yousef, and it is probably the bad water found at Assiout in June, which makes the coefficient of purity high in July at Medinet-el-Fayoum. The same conditions obtain at Deyrout; this town is, however, much nearer Assiout, and has part of the water taken away by the Ibrahimieh Canal. I think that it would be correct to compare the water at Deyrout with that at Assiout a week beforehand, and that at Medinet-el-Fayoum with that a month before at Assiout. This should be noted in future researches.

IV. THE WATER OF THE NILE CHEMICALLY CONSIDERED AS THE SOURCE OF FERTILIZERS IN EGYPT.

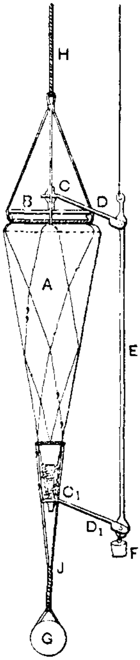
In the preceding portions I have made no reference to the suspended matter. This I propose to do here.

The soil of Egypt is enriched by no artificial fertilizers, and the mud of the Nile is its only supply of those constituents which growing crops remove from the ground. Indeed, the soil of Egypt has been formed from the mud of the Nile by its deposition during the overflowing of its banks during past ages. I had first intended to study variations in composition of the mud, but soon finding that the laws governing the variations in the quantity of the suspended matter were very imperfectly understood, I relegated my first idea to the future, and devoted what time was at my disposal to the study of these laws.

As the question of sampling was here very important I felt obliged to take the samples myself and had to devote a considerable time to traveling on the Nile for this purpose.

All samples were taken with the apparatus figured, which consisted of a funnel shaped jar A closed at one end by a cork B to which was firmly riveted a metal plate one and a half mm. in thickness, and which was covered with sealing wax over its whole surface; through this cork, and soldered to the plate passed the tap C; at the other end the tap C_1, was fixed by means of a piece of India rubber tubing, and held in place by being bound round with wire to two pieces of wood placed on each side; to the taps C and C_1, were fixed arms D and D_1, which were connected by the rod E, weighted by the weight F; a cord was attached to the upper end of E, and by pulling this the two taps could be opened simultaneously, and on releasing it the weight F caused them to close; the whole apparatus was suspended from the rope H by a net-work of cords which encircled the vessel A, and terminated in the rope J, from which hung the weight G; the capacity of the apparatus was two and a half liters.

It was used as follows: After being lowered to the required depth, the taps were opened by pulling the cord attached to E, the water entered by C_1, and the air escaped by C; when no more bubbles of air could be seen rising, the cord was released, and the apparatus withdrawn; the water was then transferred to a bottle.



The shape of the apparatus was chosen in order to facilitate the escape of all the suspended matter in the bottle.

This apparatus was also used for sounding and measuring the difference of velocity between the surface and bottom of the river, as the bubbles practically always rose in a straight line. It was assumed that the difference between surface and bottom velocity was inappreciable.

Experiments were first made to determine whether the amount of suspended matter in different parts of the river was substantially the same or not.

In the first series samples were taken in the center of the river (a) at the surface, (b) at the bottom and (c) midway with the following results: Suspended matter, (a) 176.95; (b) 194.64; (c) 188.64.

In the second a mean sample was taken, (d) in the middle of the river, and (e) as near the banks as possible, with results as follows: Suspended matter, (d) 147.66; (e) 157.35.

The velocity was in both cases about four miles an hour.

These results showed that differences did exist in different parts of the river, but that they were not serious; except, perhaps, at the surface the difference does not exceed five per cent. All samples analyzed were mixtures of water from at least four different parts of the river, and may fairly be considered as average samples.

As the difference is shown to be small, the results in Tables

I, II, and III may be taken into consideration, and will be discussed later on.

In Table XII are given the results of the determinations of suspended matter in the water at Kasr-el-Nil at short intervals, together with the height of the Nile at Assouan, the approximate velocity deduced from the time taken by the water to flow from Assouan to Cairo (information supplied by the Chief Inspector of Irrigation), and the velocity at Kasr-el-Nil calculated from the amount of suspended matter by the formula given below.

In Table XIII are the results of the analysis of corresponding samples of water at Assouan, Beni-Souef, Wasta, Atfeh, Helouan and Kasr-el-Nil; in Table XIV the results of analysis of corresponding samples at Assiout, Minieh, Beni-Souef, and Kasr-el-Nil; and in Table XV the analysis of corresponding samples at Wady Halfa and Kasr-el-Nil. The samples at Wady Halfa and Assouan are not mean samples, but were taken at half a meter below the surface, and the results should therefore be increased by about five per cent., but this does not affect the conclusions drawn therefrom.

During one voyage up the Nile, I observed that at Maghagha the current at a certain part was only running at one and a half miles per hour; at Manfalout finding a narrow creek, I ran my steam launch firmly aground, and by means of the propeller created an artificial current of ten miles an hour and a sample was taken after the lapse of some time; these samples gave the following results on analysis:

Place.	Velocity	Suspended matter.
Maghagha	1.5	21.72
Manfalout	10.0	953.6

From these I deduced the following formula, connecting the rate of flow and the amount of suspended matter: $S = 9.5\ V^2$; where S is the suspended matter in parts per 100,000, and V is the velocity in miles per hour.

By means of this formula, I have calculated the velocity of the Nile at Kasr-el-Nil on the 15th, 22nd, and 28th of August and the 4th and 15th of September, in each case with satisfactory results, considering the very approximate way of estimating the velocity, except on the 15th of August; various considerations, however, lead me to conclude that the velocity on that date at Kasr-el-Nil was greater than that stated, among which I may enumerate: (a) the river was rising very rapidly, there being an increase in four days of one meter, and it is highly probable that with such a rapid rise, a somewhat greater current should be obtained; (b) under the Kasr-el-Nil bridge only a part of the river runs, there being another branch which conveys when the river is high, another part on the Guizeh side of Gezireh; as the Nile was not very high on the 15th of August, it is probable that the bulk of the water traveled under the Kasr-el-Nil bridge, a comparatively narrow channel, and the actual velocity was by this slightly increased.

On the whole I think that the figures in Table XII confirm the formula.

It is necessary, in order that the formula hold that the following premises be granted: (a) that the density and surface tension of the mud (and therefore the size of particles) be constant; (b) that the water be mixed throughout; (c) that the water be saturated with mud.

Considering that the composition of the mud is, within very narrow limits, constant, premise (a) may be assumed to be correct; of the practical correctness of the other two, my personal observations during my voyages on the Nile during its flood, have convinced me; I noted especially the numerous currents and cross currents, the destruction of the banks, and their rapid absorption, the practical absence of much mud at the bottom of the river, and sundry smaller points.

The truth of the premises is indirectly confirmed by the agreement between the numbers found and calculated in Table XII.

TABLE XII. DETERMINATIONS OF SUSPENDED MATTER AT KASR-EL-NIL (CAIRO).

Date.	Height of Nile at Assouan.	Approximate velocity.	Suspended matter.	Calculated velocity.
August 1, 1891	87.35	2.5	29.80	....
" 11, 1891	90.44	3.85	98.48	....
" 15, 1891	91.43	3.85	188.64	4.46
" 22, 1891	92.24	3.85	134.30	3.78
" 28, 1891	92.44	3.85	160.44	4.09
September 4, 1891	92.61	3.85	147.66	3.94
" 15, 1891	92.87	3.85	151.64	3.99

I have also frequently observed that when the Nile mud is allowed to settle, it cakes after a lapse of time, and becomes difficult to remix with the water until after a certain amount of force has been used to stir it up; after being stirred up it is easy of absorption by the water until allowed to cake again.

On these observations I have founded the following theory: The suspended matter is brought down by the Blue Nile and the Atbara (and to a lesser extent by the White Nile), and has little tendency to deposit until the flow is checked; this check occurs first and principally in Lower and Middle Egypt by the drawing off of the water into the canals and basins for the irrigation of the country, and it is there that the mud is principally deposited; there is little tendency to deposit in Upper Egypt and farther south, as the velocity is to a much greater extent maintained during the depositing period; the mud-carrying waters of the Blue Nile and the Atbara, having been diluted by the comparatively clear waters of the White Nile, the river is probably by no means saturated, and cannot become so in Upper Egypt and above during the flood, as there is no great store of deposited mud; the deposited mud remains at the bottom and sides of the river during the period of low Nile and consequently low velocity, and cakes, thereby becoming a mass requiring a certain force given by a certain velocity (probably exceeding three miles an hour), to re-absorb it, and the water cannot become saturated till this "critical velocity" has been attained. On the attainment a rapid increase in the amount of suspended matter takes place in Middle and Lower Egypt until saturation is attained.

According to this theory the quantity of suspended matter should be during flood time actually greater in Middle and Lower Egypt than in Upper Egypt; the correctness of the theory is borne out by the results in Tables XIII and XV, where it is shown that the Nile at Assouan and Wady Halfa contains considerably less suspended matter than the water at Cairo.

TABLE XIII. SUSPENDED MATTER AT ASSOUAN, BENI-SOUEF, WASTA, ATFEH, HELOUAN, AND CAIRO.

Date.	Place.	Height of Nile.	Suspended matter.
August 16, 1891	Assouan	92.15	104.90
" 27, 1891	Beni-Souef	92.21	141.83
" 22, 1891	Wasta	92.21	139.50

TABLE XIII. SUSPENDED MATTER AT ASSOUAN, BENI-SOUEF, WASTA, ATFEH, HELOUAN, AND CAIRO. (CONTINUED.)

Date.	Place.	Height of Nile.	Suspended matter.
August 22, 1891	Atfeh	92.21	147.23
" 22, 1891	Helouan	92.21	143.59
" 22, 1891	Kasr-el-Nil	92.21	134.20

TABLE XIV. SUSPENDED MATTER AT ASSIOUT, MINIEH, BENI-SOUEF, AND CAIRO.

Date.	Place.	Height of Nile.	Suspended matter.
September 13, 1891	Assiout	92.87	149.82
" 14, 1891	Minieh	92.87	152.20
" 14, 1891	Beni-Souef	92.87	147.32
" 15, 1891	Kasr-el-Nil	92.87	151.67

TABLE XV. SUSPENDED MATTER AT WADY HALFA AND CAIRO.

Date.	Place.	Height of Nile.	Suspended matter.
August 15, 1891	Wady Halfa	92.44	112.10
" 28, 1891	Kasr-el-Nil	92.44	160.44

The results in Tables XIII and XIV show that the suspended matter is practically constant below Assiout, as is also the velocity; the water then is saturated here (*i. e.*, in Middle and Lower Egypt).

On the 1st and 11th of August, for which dates I have not calculated the velocity by the formula, the "critical velocity" had probably not been attained, and the water had not become saturated; premise (c) then does not hold, and therefore the formula would not be applicable.

My theory also explains the sudden increase of the suspended matter and its more gradual fall.

Although the suspended matter has its origin in the Blue Nile and Atbara (for the most part) the actual quantity in the Nile in Middle and Lower Egypt during flood time depends not on the amounts in these rivers, but on the velocity of the current.

Considering that my theory explains all the points concerning the amount of suspended matter in the Nile, it may be taken as generally true. The amount of suspended matter has no direct relation to the height of the Nile, but is dependent on the velocity, and it is a matter of extreme regret that I did not realize this at the time of making my experiments, or I should have devoted my attention to the accurate determination of the velocity.

Dredgings were made of the bed of the river at Assiout, Minieh, Beni-Souef, Wasta, Atfeh, Bedrishen, old Helouan, Dar-el-Tin, Rodah, Guizeh, Guizeh Palace, and Kasr-el-Nil during the flood, and in each case the bed was found to consist chiefly of sand, with about five per cent. of mud and small quantities of the magnetic oxid of iron mentioned above; samples were also taken just below the water and from the top of a small sand island formed by the Nile opposite Katr-el-Nabi, which had the same composition; the formation of this island, and the presence in the sand as low as Cairo of the heavy magnetic oxid of iron, which occurs above Assiout, are striking examples of the force of the current.

I have made no detailed experiments on the variations of the composition of the mud; the constituents valuable to agriculture are however practically constant in amount, and my conclusions as to the supply of mud may be taken as generally true as to the supply of fertilizers.

(V.) NOTES ON THE AGRICULTURE AND IRRIGATION OF EGYPT.

Egyptian agriculture is the mainstay of the country's prosperity, and the Nile is the mainstay of the agriculture. Fertilizers, as such, are not placed on the land, and the soil is dependent for its supply of the constituents annually removed by the plants in the mud brought and deposited by the Nile water. In former days the Nile was simply allowed to overflow its banks and inundate the country, the mud settled, and when the Nile fell again the clear water (mostly) drained off; this system is still followed in Upper Egypt, but in the remaining country the banks of the Nile have been raised and the water flows into canals, whence by a series of ramifications the water is allowed to pass on to the land. Looked at solely by the light of my theory the canal system is inferior to the older one, owing to the abundant opportunity for deposition of mud owing to the decreased velocity in the canals, and *the probable non-attainment of the "critical velocity"* in a very considerable portion of them.

This non-attainment of the "critical velocity" has a considerable importance. The Nile bed is annually cleared out by the flow of the river; the canal beds are not, and therefore they are steadily rising and helping to diminish the supply of water, and therefore fertilizers to the land. Another difficulty is being felt; the level of the land is also rising, as it receives a slight addition yearly, and in lapse of time, it must be, and in some cases is, too high for the proper flow of the water thereon. The Barrage was established in order to raise the height of the Nile, and to grapple with this difficulty. The difficulty is now again felt, and the proposals to grapple with it generally take the form of raising the height of the Nile by similar artificial structures. It is absolutely necessary not to lose sight of the fact that it is not large quantities of water that the land requires; it is the mud contained in them, and the primary object, the amelioration of agriculture, will be defeated, if, although a much larger supply of water be given to the land, this water contain less mud.

In raising the height of the Nile, nothing must be done to in any part check its velocity, and attention must be paid to keeping up this velocity to the greatest possible extent in the canals; it is better to be content with a much smaller quantity of water if it can be supplied with a great velocity, than to so raise the Nile as to allow enormous quantities of water to flow on the land at a very slow speed; it is necessary to keep up the "critical velocity" in order to make the mud deposited during the period of slow velocity available at the necessary time.

I fully realize that there are enormous engineering difficulties, but at the same time my study of the Nile has revealed to me these points which are not fully realized; it is beyond the scope of a chemist to discuss this question in more detail.

Wilcox's book on the irrigation system of Egypt gives very complete information on the engineering work of Egyptian irrigation.

(VI.) CONCLUSIONS AND SUGGESTIONS.

The conclusions from my work on the Nile are:

(1) The impurities in the Nile water are influenced by (a) the White Nile and analogous tributaries; (b) the Blue

Nile and analogous tributaries ; (c) the impurities taken up during its flow ; (d) the self-purification it undergoes, of which (d) is the most important.

(2) The water of the Nile, at Cairo, is a moderate drinking water, and not an excessively bad one, as has been maintained ; after filtration through sand, as practised by the Cairo Water Company, not much exception can be taken to it. The Cairo Water Company's supply is on the whole good.

(3) After filtration through "polarite" it becomes a most excellent drinking water, fully equal and in many cases superior to the water supplied to great English towns.

(4) The Nile in its downward flow takes up impurities both mineral and those due to sewage ; these are, however, insignificant when compared with the great bulk of water and to the self-purification.

(5) The amount of nitric acid is remarkably small.

(6) The purification and deficiency of nitric acid are largely due to the iron minerals in its bed (*e. g.*, magnetic oxid of iron, ferrous silicate, etc.).

(7) The quality of the water is worst just before the annual rise, and at its best just after the attainment of its maximum

(8) The suspended matter, which supplies the fertilizers necessary to the agriculture of the country, is not only dependent on the quantity brought down by the Blue Nile, etc., but also and more especially on the velocity of the river.

(9) Portions of the suspended matter become deposited on the bed of the river, as the current slackens, and a certain "critical velocity" is necessary to stir this up again, so as to be again taken into suspension.

(10) After the "critical velocity" has been attained, the water saturated with mud, the relation between suspended matter (S) and velocity (V) is expressed by the formula $S = 9.5 V^2$.

(11) After the water is saturated (which only occurs in Middle and Lower Egypt) the quantity of suspended matter is greater than that found in the Nile in Upper Egypt and above.

(12) Any diminution of the current of the river, and especially the prevention of the attainment of the "critical velocity" at the proper time will cause a loss of suspended matter and therefore a detriment to agriculture.

I can only look upon my work as preliminary to a thorough investigation of the Nile in the future; there are many points to be determined (*e. g.*, the "critical velocity," the actual amount of fertilizers necessary, and the lowest safe velocity, the laws that govern the settling of the mud, and the purification of the water, the composition of both water and mud, and the part played by each constituent) and these I leave as a legacy to my successors.

As Egypt depends on the Nile, it is imperative for the Egyptian government to have the fullest information on the Nile at their disposal, in order to control the river so as to obtain the greatest possible benefit therefrom. My work was chiefly done at the Khedivial Laboratory, at Cairo, but I found that the rough laboratory that I fitted up on board the steam launch, No. 74, was of great assistance, and future investigation should be carried on in a laboratory of this description; it would require a steamer large enough to hold thirteen or fourteen persons, and powerful enough to steam six miles against the full stream, and of low draught,—preferably a stern-wheeler.

At least five years should be devoted to the work, and the total expenses would be:

Initial expenses	£1650
Five years, at £1903	9515
Total	£11,165

The Egyptian government should be prepared to find that sum. A great deal of work could also be done on the minerals of Egypt at the same time.

My conclusion (12) is highly important to the irrigation service, and I recommend it to the notice of the Public Works Department.

This paper contains the substance of a report made by me to the Director of the Sanitary Administration.

In conclusion I must express my warmest and most grateful thanks to Dr. Hussein Off, third chemist in the Khedivial Laboratory for his aid; the devoted way in which he worked with me, often far into the small hours of the morning, has contributed greatly to the completion of my work.

ELECTROLYTIC SEPARATIONS.

BY EDGAR F. SMITH AND J. BIRD MOYER.

IN a former communication we demonstrated by a sufficient number of carefully made experiments that mercury and bismuth could not be separated electrolytically in a nitric acid solution. This was in line with the observations of Smith and Saltar,[1] who proved conclusively that copper and bismuth could not be separated under analogous conditions, and further that the statement in regard to the separation of bismuth and lead was incorrect. Pursuing our original intention of studying the electrolysis of metals in the presence of free nitric acid we offer the following additional experience in this field of investigation. We naturally expected little trouble, and indeed met with very little in our efforts to separate

Mercury from Lead.

1. Ten cc. of mercuric nitrate solution (= 0.1150 gram of metallic mercury), one cc. of lead nitrate solution (= 0.0126 gram of lead dioxide), and twenty-five cc. of nitric acid of sp. gr. 1.3, were diluted to 175 cc. and electrolyzed with a current liberating 1.3 cc. of electrolytic gas per minute. The precipitated mercury weighed 0.1151 gram, and the lead dioxide equaled 0.0123 gram. An examination of the mercury did not reveal any admixed lead.

2. In this experiment the quantities of lead and mercury were the same as in 1; the volume of nitric acid was increased to thirty cc. while the current registered 1.8 cc. of electrolytic gas per minute. The mercury deposit weighed 0.1150 gram and the dioxide of lead equaled 0.0126 gram.

In three other experiments in which the volumes of the added nitric acid (sp. gr. 1.3) equaled five cc., ten cc., and fifteen cc., respectively, the precipitated mercury contained metallic lead in varying but very considerable amounts.

[1] *J. Anal. Appl. Chem.*, 7, 128.