



GLOBAL JOURNAL OF RESEARCHES IN ENGINEERING: E
CIVIL AND STRUCTURAL ENGINEERING
Volume 14 Issue 2 Version 1.0 Year 2014
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

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By Dr. Faiz Al-Kathily

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An integrated 5,50 m high Direct filtration unit was constructed in the laboratory, it included four main units: an axial flocculating unit, a filtration unit, injection unit for pumping coagulants and clay materials, and a backwashing unit, a piezometric board is also included tot give reading at each 10cm of filter height . Water is supplied to the system through a constant head tank by gravity action. filtration is done through two mediums, a crushed brick layer2 to 5mm sizes(30to40)cm deep and a quartz sand layer 0-.60to 0.75mm (30to40)cm deep.

GJRE-E Classification : FOR Code: 290801



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An integrated 5,50 m high Direct filtration unit was constructed in the laboratory, it included four main units: an axial flocculating unit, a filtration unit , injection unit for pumping coagulants and clay materials, and a backwashing unit, a piezometric board is also included tot give reading at each 10cm of filter height . Water is supplied to the system through a constant head tank by gravity action. filtration is done through two mediums ,a crushed brick layer2 to 5mm sizes(30to40)cm deep and a quartz sand layer 0-.60to 0.75mm (30to40)cm deep.

The partial part was done in two stages:-

The first stage included the laboratory procedure, using the constructed filtration system, Baghdad water supply was used, with the addition of kaolin (fine mud used as turbidity)to increase turbidity to find the best combination of variables, loading ,to highest water yield together with highest efficiency, experiments were run to find the effect of filtration rate, type &and depth of filtration materials, effect of coagulating material and added catalyst in addition to the control of flocculation time and velocity gradient.

The second stage included the study of the effects of magnitude of turbidity and type of coagulating materials on water yield & on efficiency of filtration system, experiments of this stage were run in habbaniyah, using lake water and water treatment plant of touristic village, by eliminating the sedimentation stage of the plant, the pressurized filtration unit was used, 0.2to0.5mm charcoal, 0.2to 0.5mm sand,

Results of Above Showed that

1. It is possible to use direct filtration procedure in both laboratory and field with increasing efficiency through proper control of mixing, turbidity, filtration rate and velocity gradient.
2. Habbaniyah Lake water maximum Turbidity is around 70,0 mg/l .
3. TSS in the lake water is between 600-700 mg/l which is expectable for drinking purpose.
4. Dissolved Oxygen is high in Habbaniyah Lake water which give good indication for the good Quality of water and less Organic materials.

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5. Direct filtration gives V. good Results for filter working cycle, and quantities of water production& Quality.
6. It is recommended to Use Polymer with Alum for Coagulation for better Results.
7. Experimental field tests Filter efficiency increased when using polymers after 8.0 hr of working,
8. Experimental Tests using Habbaniyah water and Polymers with Alum as coagulants shows that Filter working time increased up to 27,0 hours.
9. Filtration efficiency about 67% at field tests, and up to 98% at laboratory Tests.
10. Experimental Tests using Habbaniyah water gives clear product water 1.48 FTU. (1.92 NTU).
11. It is important to check Coagulant potential value to have better Results.
12. Pressure Filters can be used for direct filtration.IN ADDITION TO Rapid Gravity Filters.
13. Feasibility Study shows a big advantages of constructing water treatment plants Using Direct filtration from Habbaniyah Lake with capacities equal or bigger than 500,000 m3 /day,

I. PURPOSE

The purposes of the direct filtration process include: compliance with treatment technique regulatory requirements; targeting impurities; and producing safe and aesthetically pleasing drinking water. When source water is generally within the turbidity range of 1 to 5 NTU, it may be a candidate for direct filtration.

II. INTRODUCTION

Water purification is the removal of contaminants from untreated water to produce drinking water that is pure enough for the most critical of its intended uses, usually for human consumption. Substances that are removed during the process of drinking water treatment include suspended solids, bacteria, algae, viruses, fungi, minerals such as iron, manganese and sulfur, and other chemical pollutants such as fertilisers.

Measures taken to ensure water quality not only relate to the treatment of the water, but to its conveyance and distribution after treatment as well. It is therefore common practice to have residual disinfectants in the treated water in order to kill any bacteriological contamination during distribution.

World Health Organization (WHO) guidelines are generally followed throughout the world for drinking water quality requirements. In addition to the WHO guidelines, each country or territory or water supply body can have their own guidelines in order for consumers to have access to safe drinking water.

Natural/or Artificial Lakes in Iraq normally extending over a huge area that trapped large amounts of Turbidity. Lakes provide long detention times, low water speed that can be negligible, allowing for adequate settling of the larger turbidity particles and suspended solids. In general, larger lakes have lower turbidity levels. Algae are common and normal inhabitants of surface waters and are encountered in every water supply that is exposed to sunlight. Algae typically range in size from 5 to 100 microns.

Many microorganisms commonly found in source waters do not pose health risk to humans, As Filters represent the key unit process for particles removal in all surface water treatment. Optimization used prior to the filtration process will control loading rates while allowing the system to achieve maximum filtration rates. Direct filtration is one of several treatment processes that can be applied in combination with others to produce potable water. Low turbidity (<20 NTU) and algae count in the order of 106 units/liter among other factors,

III. HISTORY OF THE GRAVITY WATER FILTER

1835... London, England. Queen Victoria recognized the increasing health dangers of the drinking water supply. Cholera and typhoid epidemics were commonplace.

She requested John Doulton (of later to become Royal Doulton), to produce a water filter with his ceramic making capabilities. Using various earth and clay materials, he created the first gravity water filter stoneware, Doulton water filters. With her satisfaction in the filter, Queen Victoria bestowed upon Doulton the right to apply the Royal Crest to each of his units.

1862... John Doulton's son, Henry Doulton introduced the Doulton Manganour (new, efficient purifying medium which could be readily renewed), carbon water filter. With Louis Pasteur's new findings about bacteria in this same period, a more advanced understanding of bacteria made it possible for the creation of a porous ceramic which could filter out tiny organisms. Gravity fed water filtration! and the Berkey...? We're getting there...

1901... King Edward VII knighted Henry Doulton and honored his company use to the word ROYAL in reference to its products. Hence the name "Royal Berkey", one of the larger gravity water filter units available today. Doulton's water filters gained popularity and wide spread use by hospitals, laboratories and

residential water filtration throughout the world as far away as Africa and the Middle east.

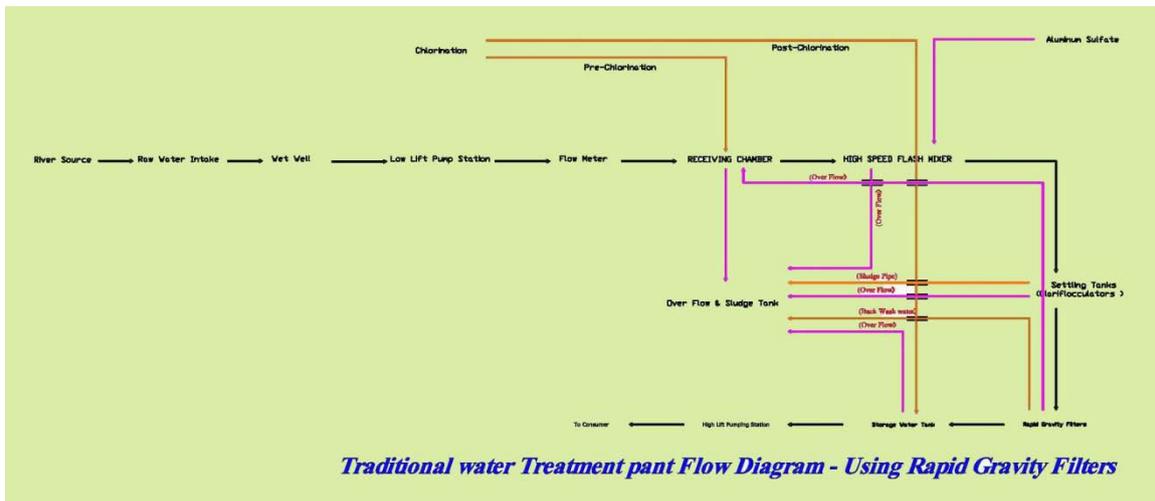
Throughout the decades, the Doulton company modified the ceramic filters by adding small, pure silver particles (anti-microbial), which made the filter elements self-sterilizing and they registered the trade name "British Berkefeld". Once these improvements were made, the gravity filters became popular with, and trusted by relief organizations such as UNICEF, the Peace Corps, Red Cross and used in over 140 countries throughout the world.

1998...Through a distribution partnership with British Berkefeld, the US based company, "New Millennium Concepts", began distributing their products locally. NML pushed the envelope of the product and created the "Black Berkey" purification element. Black Berkey purification elements are more powerful than any other gravity filter element currently available. They were tested with 10,000 times the amount of pathogens required for standard protocol and removed 100% of the pathogens (tested under an electron microscope), setting a new standard in water purification.

IV. PROCESSES FOR DRINKING WATER TREATMENT

A combination selected from the following processes is used for municipal drinking water treatment worldwide:

- Pre-chlorination - for algae control and arresting any biological growth
- Aeration - along with pre-chlorination for removal of dissolved iron and manganese
- Coagulation - for flocculation
- Coagulant aids, also known as polyelectrolyte - to improve coagulation and for thicker floc formation
- Sedimentation - for solids separation, that is, removal of suspended solids trapped in the floc
- Filtration - removing particles from water
- Desalination - Process of removing salt from the water
- Disinfection - for killing bacteria.



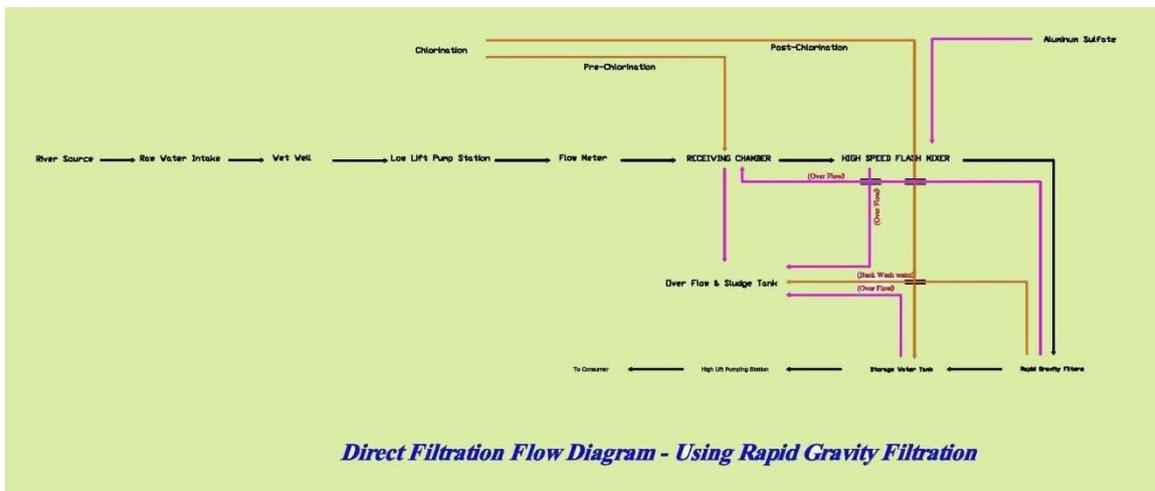
Technologies for potable water treatment are well developed, and generalized designs are available that are used by many water utilities (public or private). In addition, a number of private companies provide patented technological solutions. Automation of water and waste-water treatment is common in the developed world. Capital costs, operating costs available quality monitoring technologies, locally available skills typically dictate the level of automation adopted.

V. ADVANTAGE OF DIRECT FILTRATION PROCESS

Several advantages can be realized when compared to the conventional systems. The advantages of this system may be summarized as follow.

- has low capital and running cost, Lose (1951) and Monscvitz (1978),
- easy to construct and to use, Foly (1967) and Hutchison (1977),

- requires minimum number and small size of the treatment units, thus occupies less surface area as compared to most conventional systems,
- Requires less number of labor, facilities, and equipments, companied with the conventional systems.
- require less dose of chemicals and coagulants (Fadel 1989),
- has a reliable effluent with negligible algae problems (Fadel and Barakat, 2004; Fadel et al., 2004).
- can be applied for several types of water having low, medium, or high turbidity,
- can be washed by raw water with suitable period of ripening, and
- does not require periodical surface and cleaning, thus produces less amount of wastewater.



VI. EFFECT OF FILTER DEPTH ON THE REMOVAL EFFICIENCY

It is well known that, the filter depth has a direct relation with the filter efficiency, i.e., increasing the filter depth will increase the filter efficiency. The effect of filter depth on the removal efficiency of the direct filter. The new investigations are, when the filter depth is shorter than 0.4 m, no significant efficiency is observed. For filter depth ranging from 0.4 -0.8 m, a significant increase is observed in the filter efficiency.

VII. EFFECT OF FILTRATION RATE ON THE REMOVAL EFFICIENCY

1st- The filtration Rate slowly affect the removal efficiency when filtration Rate $< 4 \text{ m}^3/\text{m}^2/\text{h}$.

2nd- The removal efficiency reaches up to 80 %. When filtration rate is $4 \text{ m}^3/\text{m}^2/\text{hr} > \text{filtration Rate} < 12 \text{ m}^3/\text{m}^2/\text{hr}$,

3^d- With more increase in filtration Rate, the removal efficiency comes down to less than 40%.

VIII. EFFECT OF MEDIA PARTICLE SIZE ON REMOVAL EFFICIENCY

The Media particle size strongly affects the filter efficiency.

1st- High effect of grain size on the performance of direct filtration. Removal efficiency comes down to insignificant value at using particle of size $> 5\text{mm}$.

2nd- Particle size of 0.1-2 mm is recommended. At some cases of pre-treatment work, particle size greater than 3 mm may be of use.

IX. EFFECT OF ALUM DOSE CONCENTRATION ON THE REMOVAL EFFICIENCY

Several factors may Govern the optimum dose of alum such as, size of Turbidity particles, turbidity level, and the G potential of Coagulation, surface loading, etc. many studies shows the effect of coagulant dosage on the performance of direct filtration, some stated that, there exist an optimum dose at which the filter produces high effluent efficiency.

X. FILTRATION MECHANISM

Filtration depends mainly on kind of particles, and the filter media. In addition to Rate of filtration, Dosage and type of coagulants Used In general One or more of below factors affect the filtration:-

1st- deposit mechanism, as the particles bigger than the size of media porosity will be settled over the media, also the suspended solid take a specifies path depend mainly on porosity but even though some of the particles pass through the media, as there are some

factors affecting the mechanism such as direct distortion, Brownian movement or van der waals forces,

2nd- fixation mechanism, which is the sedimentation of particles over the filter Surface as part of slow filtration flow, or vibration of particles because of different electrical charges ,or van der waals forces.

3^d- detachment mechanism, as part of above forces and particles being catch either over the surface /or in side media porosity, the filtration rate may increase, and the flow may change from laminar flow to Turbulent, so particles may separated again and move deep or even pass through the filter media, this can be solved using stronger polymers, and variable filtration flow,

To solve above we can do either

1st- increase particles size inside the media be injecting polymers inside the filter.

2nd- reduce particle size inside the passing solution by pumping water from down to up.

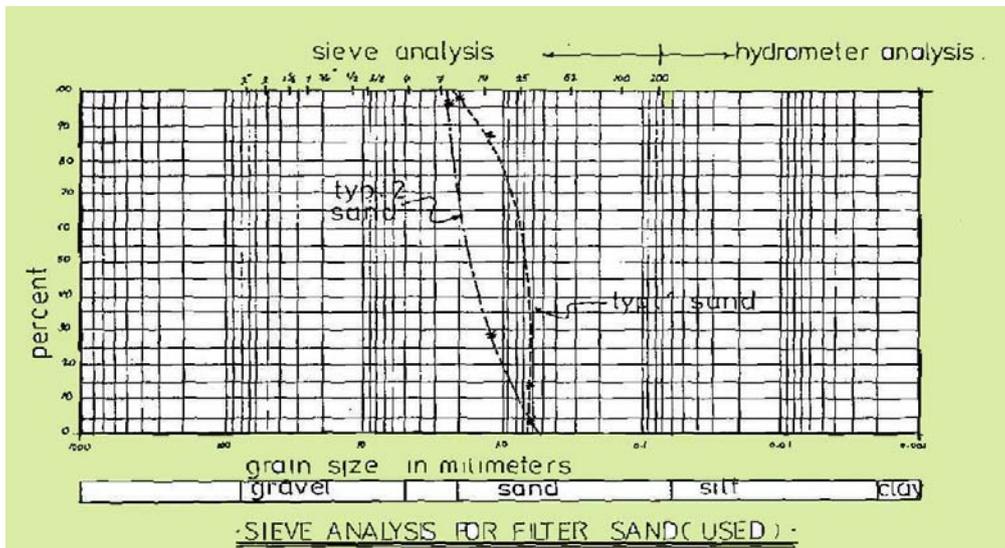
3^d- Reduce filtration rate. Inside each layer. Which can be done using radial filtration?

XI. THEORETICAL ANALYSIS OF FILTRATION

As deep filter media used to inshore removal of collides, then continues increase in head losses till the filter reach its blocked stage. And then Back wash should be done.

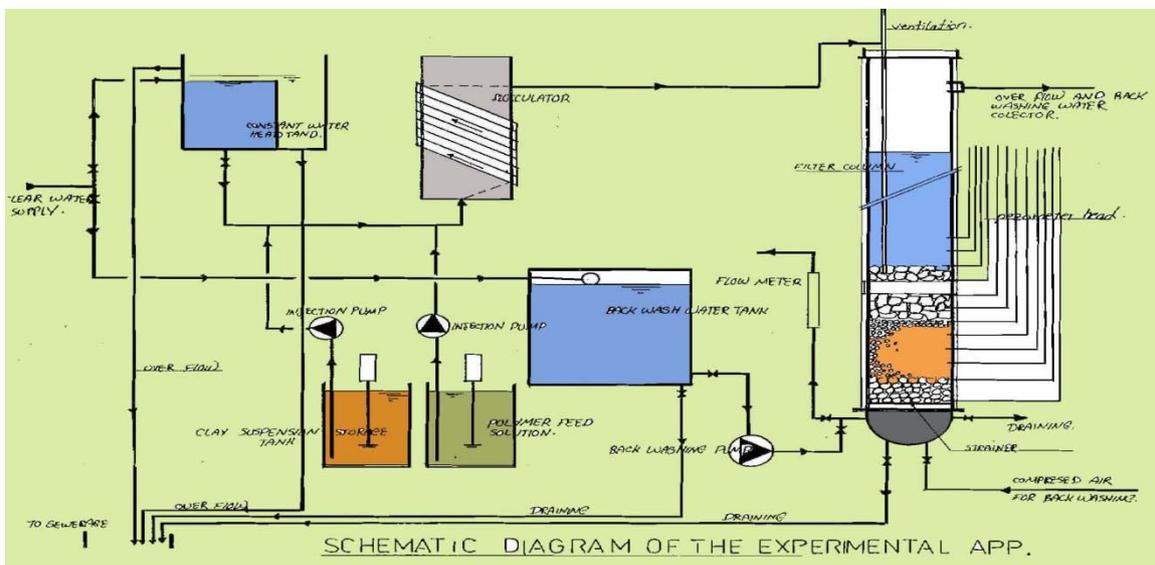
XII. LABORATORY TESTS PERFORMED

An integrated 5,50 m high Direct filtration unit was constructed in the laboratory, it included four main units: an axial flocculating unit, a filtration unit , injection unit for pumping coagulants and clay materials, and a backwashing unit, a piezometric board is also included tot give reading at each 10cm of filter height . Water is supplied to the system through a constant head tank by gravity action. filtration is done through two mediums ,a coarse media layer with 2 to 5mm sizes (30to40)cm deep, and a quartz sand layer 0-.60to 0.75mm (30to40)cm deep.



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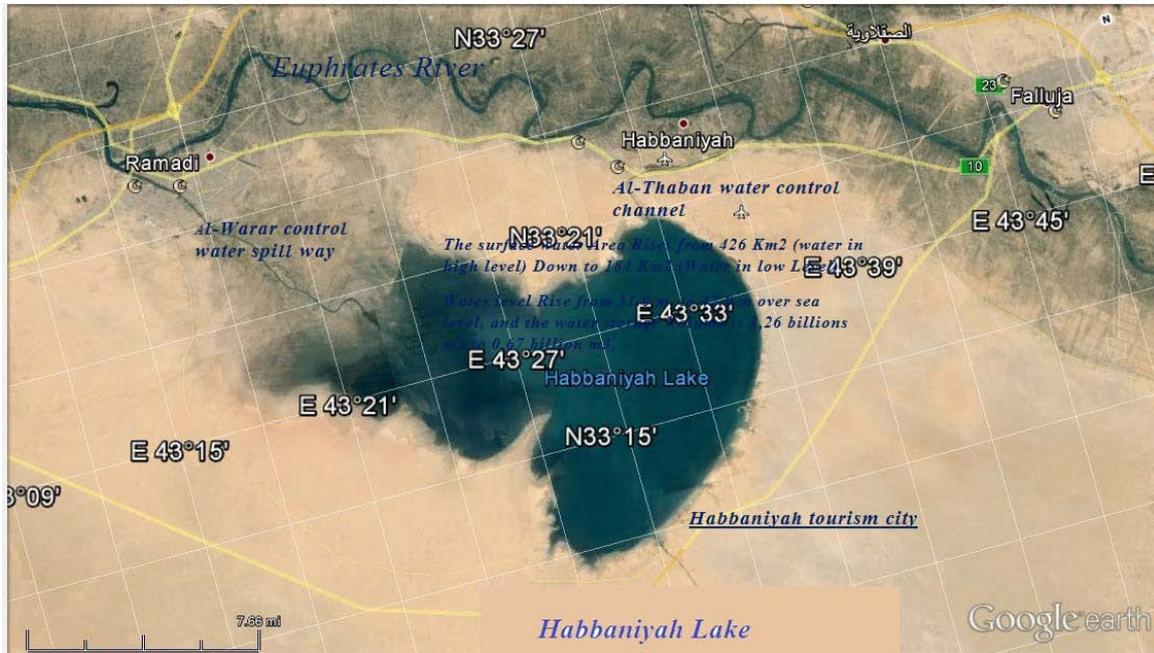
highest water yield together with highest efficiency, experiments were run to find the effect of filtration rate ,type & depth of filtration materials, effect of coagulating material and added catalyst in addition to the control of flocculation time and velocity gradient.



XIII. HABBANIYAH LAKE

All Results mostly theoretical in laboratory, will never give a good idea for the advantages of direct filtration for the rezones that all environmental changes are mostly controlled in the lab, with some real exceptions that there are many field test using the Direct filtration using water from lakes in many country such as USA ,UK ,Egypt ,Brazil., Argentina and allot others , all the test shows that this method is very good in producing a good quality of Drinking water and long Run of filters with a special parameters for each individual case, this lead the need to make field test for the water of Habbaniyah lake in Iraq which is located in

the middle of Iraq ,in the south west of Baghdad city (Capital of Iraq) ,see map below



This artificial lake is deeded with water from Euphrates River through Al-Warar control water spill way which have a maximum discharge of 2,800 m3/sec and channel Total length of 8,000 m, the water is drown off through Al-Thaban water control channel length 9,300 m that have normal water discharge of 200 m3/sec, the south of Habbaniyah lake was connected with water channel to Razzazah Lake and Hour Abo Debis the east

side of the lake is a low level Ground which can be flood when water level's rises in this Lake,

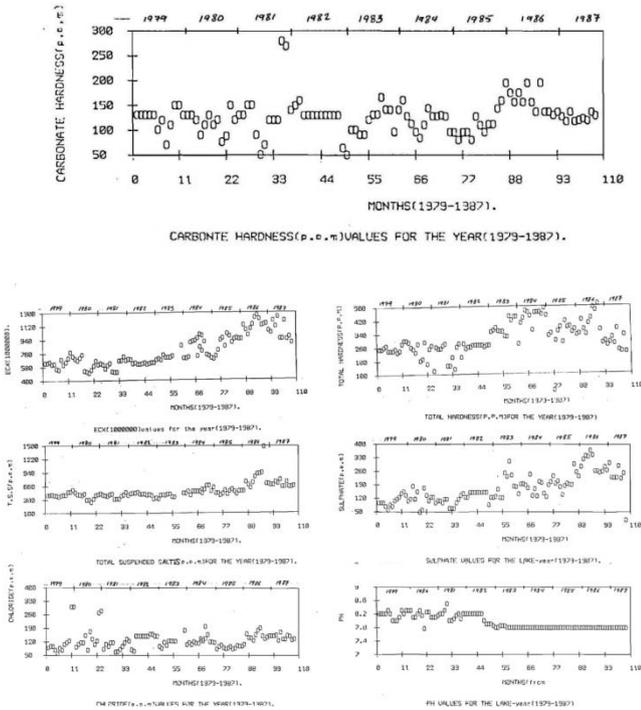
The surface water Area Rises from 426 Km2 (water in high level) Down to 184 Km2 (Water in low Level)

Water level Rise from 51.0 m, to 42.0 m over sea level, and the water storage Volume is 3,26 billions m3 to 0,67 billion m3,



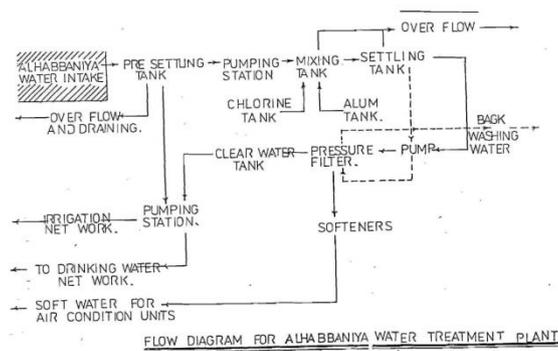
a) Lake Water Analysis

Some water analysis was made for water samples collected near -Thaban water control channel collected by ministry of agriculture and water recourses , all test results with maximum Turbidity <100 mg/l which is very convenient for Direct Filtration.



b) Existing Water Treatment Plant for Habbaniyah Tourism City

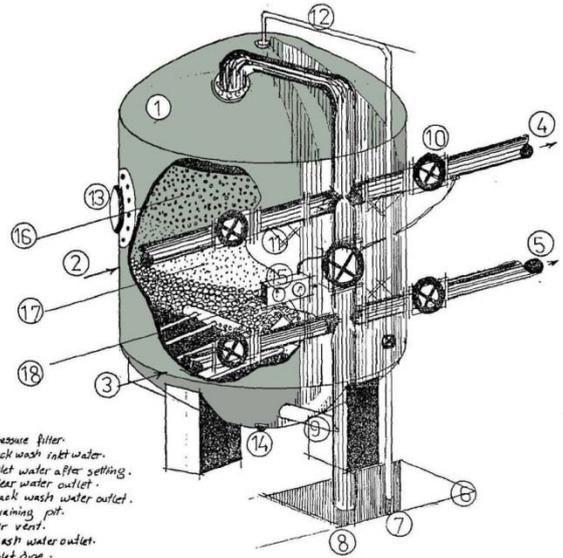
Located north east of Al-Thaban water control channel, consist of four compact Units, with total water production of 2,000 m³/day,



Raw water pumped from the lake to underground water storage tank Depth 8,0 m ,water stays for about one hour then water is pumped to the coagulation & settling tanks .

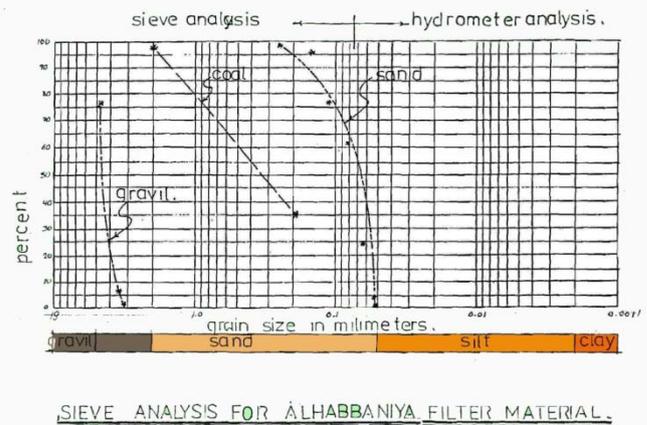
Because of the traditional treatment sequence used in this existing plant, a hard work has to be done to modify the plant to direct filtration system and start the field tests,

c) Filter Units Used In The Plant



PRESSURE FILTER AT ALHABBANIYA LAKE

There are four filter Units in the Existing plant, pressure Type filters ,Vertical Type with Dia .1,90 m and height of 2.10m water pumped from settling tank Via Ercole Marelli pump to the filters, the same pumps are Used for Back washing of filters through Control System. Back Wash water is pumped back to the lake. All inlet and out let of filters are provided with pressure gages, and the back wash normally done automatically. The back wash was done usually in four stages to prevent the flushing of the filter media, filters with multimedia three layers equal in Depth, Aggregate & fine Sand, and Coal.

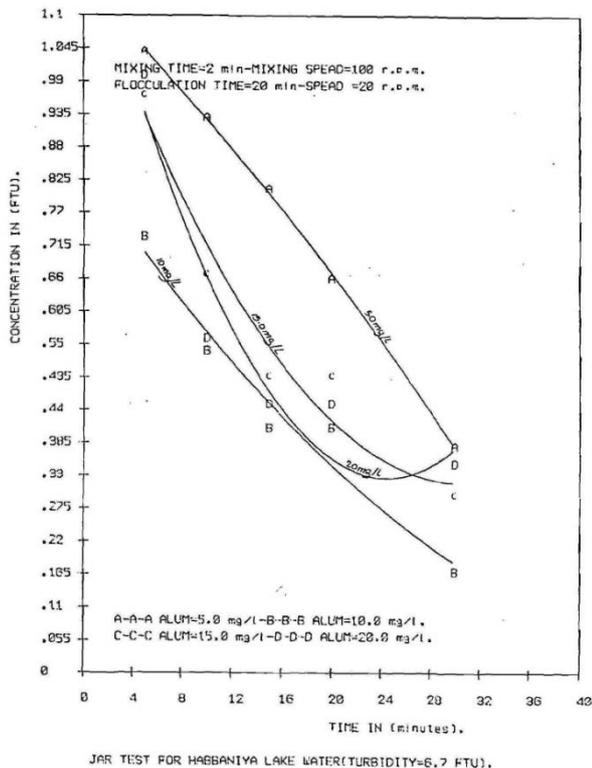


SIEVE ANALYSIS FOR ALHABBANIYA FILTER MATERIAL

XIV. FIELD TESTS

a) Jar Test

At the beginning we have to choose which Dose of Alum is the Best for Habbaniyah Lake, a jar Test was performed; Attached figure shows the relation between dosing of Alums and filters performers.



b) Experimental Field Test

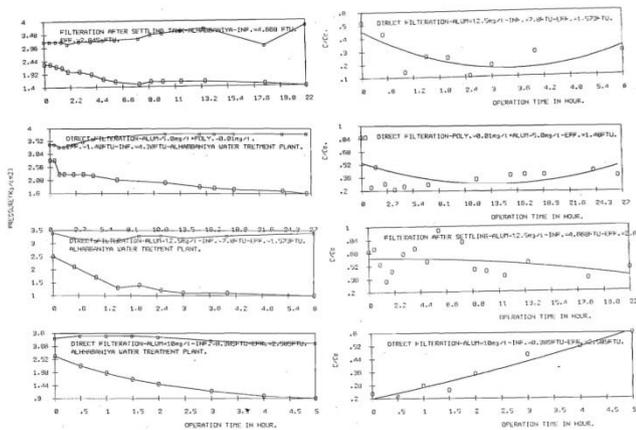
To start the test at site using Direct filtration, and Lake water first a diversion has been made for Unit No.3, the Primary Settling tank was canceled, two group of test was made using lake water with Turbidity >10.0 mg/l first using Alum As coagulant, and second Group used Alum in addition to Polyelectrolyte.

No.	Test Type	Av. Inlet Water Turbidity in (FTU)	Av. Out let Turbidity in (FTU)	Filter efficiency	Type of Coagulants Used in the Test	Time of operation in (hr.)	Water production in (m3)
1	Direct Filtration	8.385	2.585	69.17	Alum 10mg/l	5.80	211.99
2	Direct Filtration	7.80	1.573	79.83	Alum 12.5 mg/l	6.00	271.50
3	Direct Filtration	4.39	1.48	86.25	Poly. 0.01mg/l + Alum 5 mg/l	27.00	1189.88
4	Direct Filtration	4.668	2.645	43.33	Alum 12.5 mg/l	22.00	1353.13

c) Field Test Results

Field first group of tests used Alum as Coagulant with Dosage of 10.0 mg/l and 12.5 mg/l, water produced with very high Quality compared with conventional treatment sequence but the filter working time was about 5-6 hours compared with 12 hours if the plant is working with its original sequence, test was repeated using assistance coagulants like polymers with Dosage of 0.01 mg/l in addition to Alum dosage concentration 5.0 mg/l, filter working time increased up

to 27.0 hours, with filtration efficiency about 67%, and clear product water 1.48 FTU, see Table above, below figure showing production of water relative to head losses, and head losses with time,



It was also clear that filter efficiency increased when using polymers after 8.0 hr of working,

d) *Experimental Results*

- i. Habbaniyah Lake water maximum Turbidity is around 70,0 mg/l .
- ii. TSS in the lake water is between 600-700 mg/l which is expectable for drinking purpose.
- iii. Dissolved Oxygen is high which give good indication for the good Quality of water and less Organic materials.
- iv. Direct filtration gives V. good Results for filter working cycle, and quantities of water production & Quality.
- v. It is recommended to Use Polymer with Alum for Coagulation for better Results.
- vi. Filter efficiency increased when using polymers after 8.0 hr of working,
- vii. Filter working time increased up to 27,0 hours.
- viii. filtration efficiency about 67%
- ix. clear product water 1.48 FTU
- x. It is important to check Coagulant potential value to have better Results.
- xi. This shows clearly that pressure Filters can be used for direct filtration in addition to Rapid Gravity Filters.

e) *Experimental Equations Resulted*

Experimental equations for the Total water Production (one filter cycle), Using Habbaniyah water, Direct Filtration, & Pressure filters can be show As Follow

- i. Using Alum As main Coagulant , with Dosage of 10.0 mg/l,

$$WP=68765*(\text{LOG } 2400 / \text{Delta H})$$

- ii. Using Alum As main Coagulant , with Dosage of 12.5 mg/l,

$$WP=637.37*(\text{LOG } 2400 / \text{Delta H})$$

- iii. Using Alum & polymer As Coagulant , with Dosage of 5.0 mg/l Alum ,in addition to Poly.0.01 mg/l,

$$WP=1976.33*(\text{LOG } 2400 / \text{Delta H})$$

- iv. Using Alum As main Coagulant , with Dosage of 15,0 mg/l,

$$WP=3176.59*(\text{LOG } 2400 / \text{Delta H})$$

Where:-

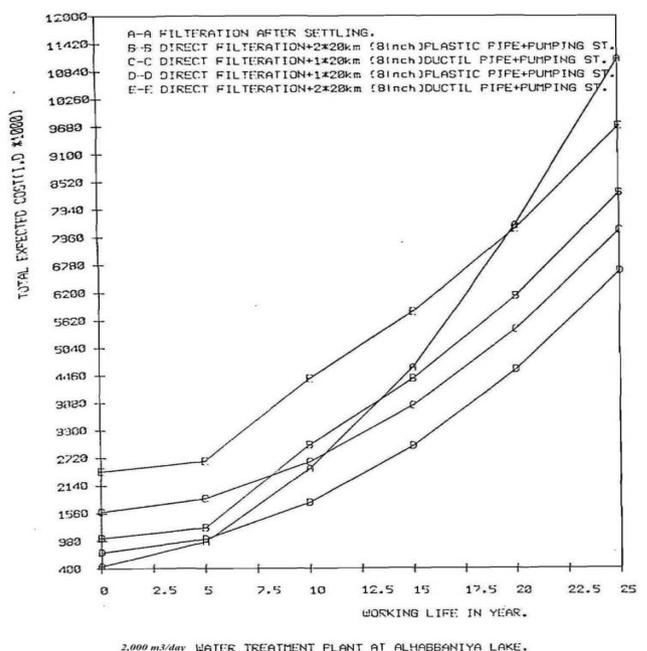
WP = Water Production in m3/filter Run (till Back Wash is required)

Delta H = Total Filter head losses at the beginning (when t=0)

XV. FEASIBILITY STUDY

As any work needs to be evaluated through feasibility study, in which all future expenses should be considered as effective factors, Habbaniyah Lake is surrounded with many big cities, so this study will conceder falluja city to evaluate using direct filtration water plants ,the city is about 20 Km to the east ,also results will be compared with conventional treatment plants using Euphrates River water for this comparison we suggested using plants with capacities of 2,000 m3/day, 100,000 m3/day , 250,000 m3/day , 500,000 m3/day,

Estimated costs for settling tanks is about 20-30% of total plant initial costs, this study will consider the running and maintenance cost of the plants, keeping in mind that the expected annual influence in worker salary is about 5%,and the influence in construction materials and equipment is around 33%, annual Bank found of 10% is considered, below is a figure for 2,00 m3/day plant , the study clearly shows that this size of plants will not give any benefit before 5 years,



2,000 m3/day WATER TREATMENT PLANT AT ALHABBANIYA LAKE.

Feasibility study for Constructing Direct Filtration plants with capacity of 100,000 m³/hr and 250,000 m³/hr shows that there is no benefits compared with conventional plants if constructed inside Al-Falluja city on Euphrates River,

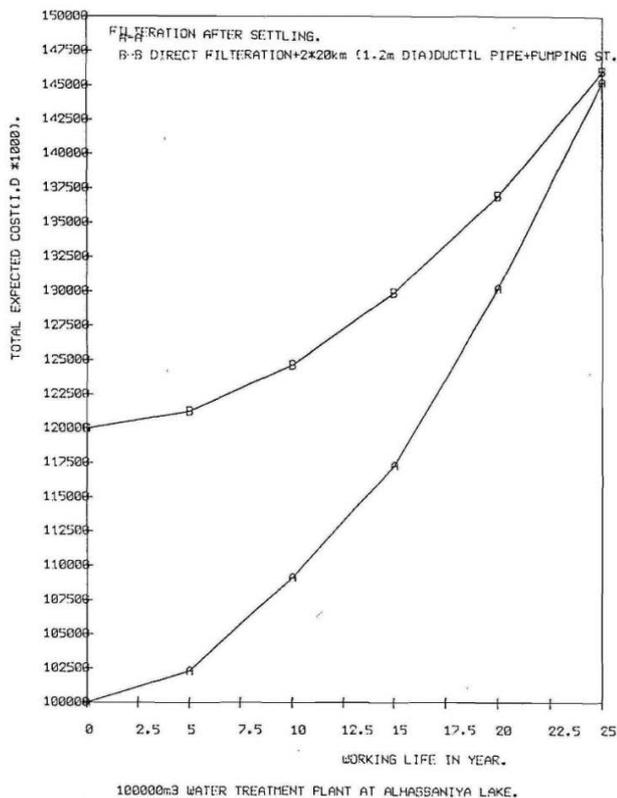
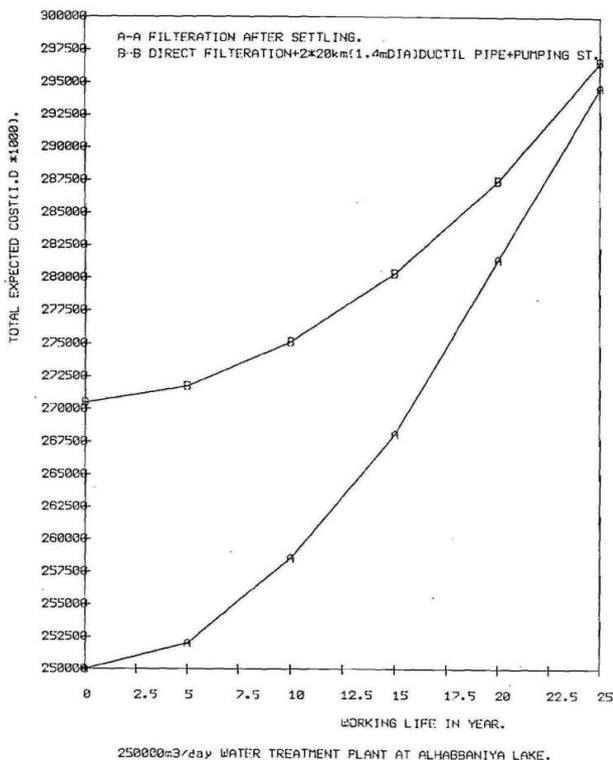
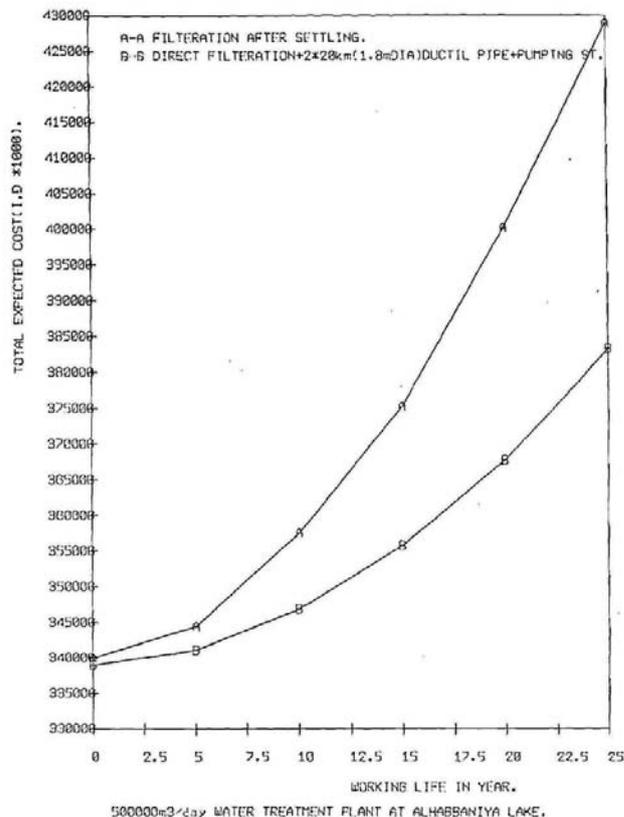


Figure below for water treatment plant with capacity of 500,000 m³/day using Direct filtration, it can be seen clearly the advantage of such plants and the benefit in its low initial costs too,



a) Results from Feasibility Study

It is clearly understood from above study, there is a big advantages of constructing water treatment plants Using Direct filtration from Habbaniyah Lake with capacities equal or bigger than 500,000 me /day,

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