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Direct Filtration using Surface Lakes Water in Iraq

By Dr. Faiz Al-Kathily

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Direct Filtration using Surface Lakes Water in Iraq

Dr. Faiz Al-Kathily *(BSc, HDPE, MSc, PHD)*

I. Direct Filtration using Surface Lakes Water in Iraq

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.

There is no unique solution (selection of processes) for any type of water. Also, it is difficult to standardize the solution in the form of processes for water from different sources. Treatability studies for each source of water in different seasons need to be carried out to arrive at most appropriate processes.

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.

II. Purpose

This research aims at elimination of the sedimentation stage from water purification systems, here waters supplied from lakes. In this case, chemical are used to coagulate any remaining suspended materials before the filtration stage, chemical used include alum with some catalyst, such as poly electrolytes this is called Direct Filtration.

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 10 NTU, it may be a candidate for direct filtration.

This study addresses the applicability of Direct Filtration (DF) as a candidate process to produce potable water from Lakes or areas under the influence of those Lakes,

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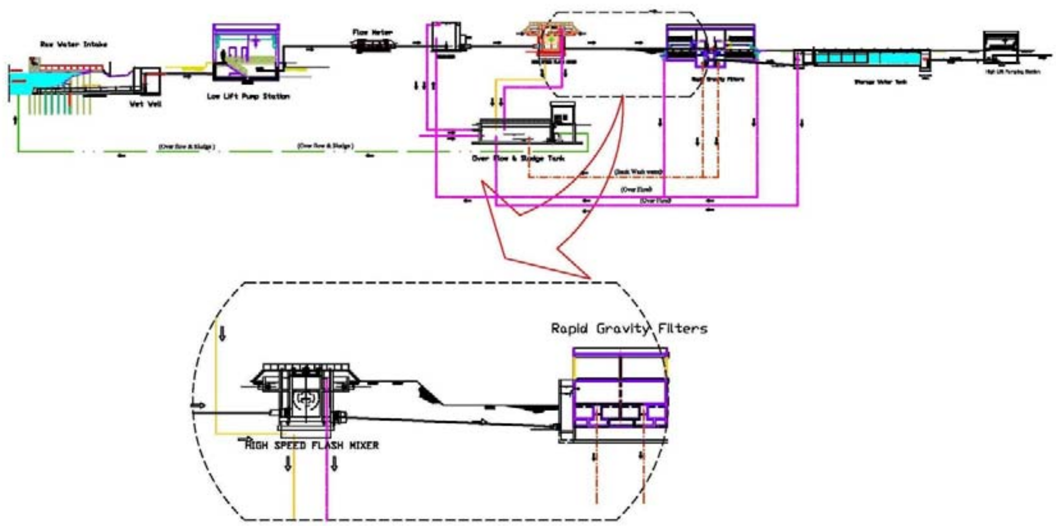
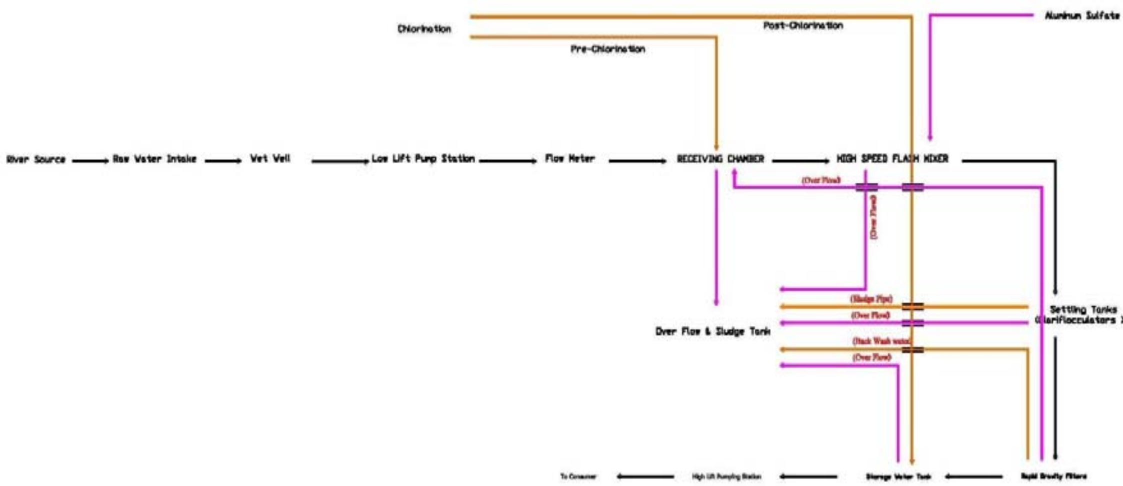
Author: *Kingdom of Jordan/ Amman/Jebeeha/ almanhal intersection/ gaowhar alsakili Road. e-mail: faiz_alkathily@hotmail.com*

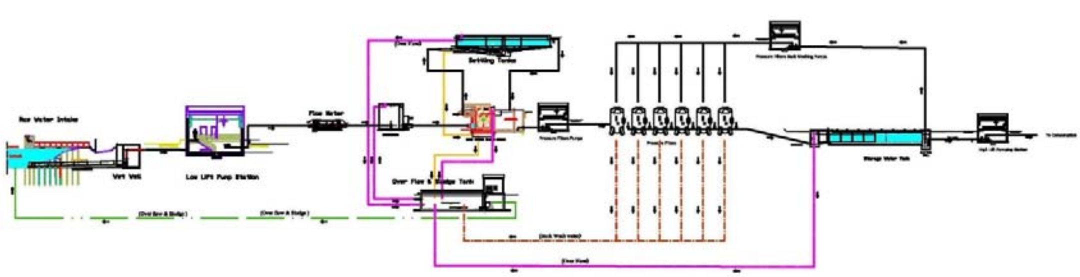


Direct Filtration Hydraulic profile - Using Rapid Gravity Filters

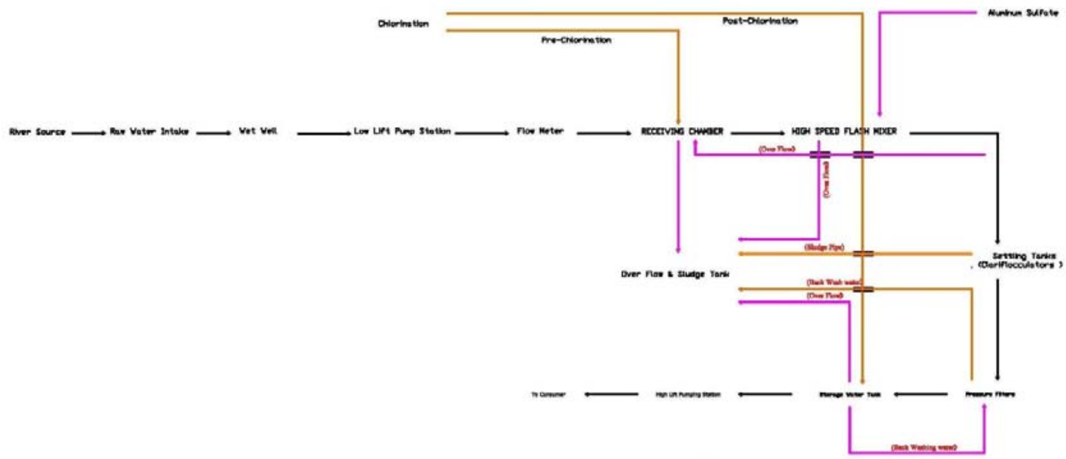


Traditional water Treatment pant Flow Diagram - Using Rapid Gravity Filters

Higher filter capacity is achieved by obtaining a more uniform solids loading distribution and by utilizing as much as 98% of the media bed. Direct filtration differs from conventional treatment in that it does not provide for solids removal by settling but does allow for mixing of coagulant chemicals prior to filtration.



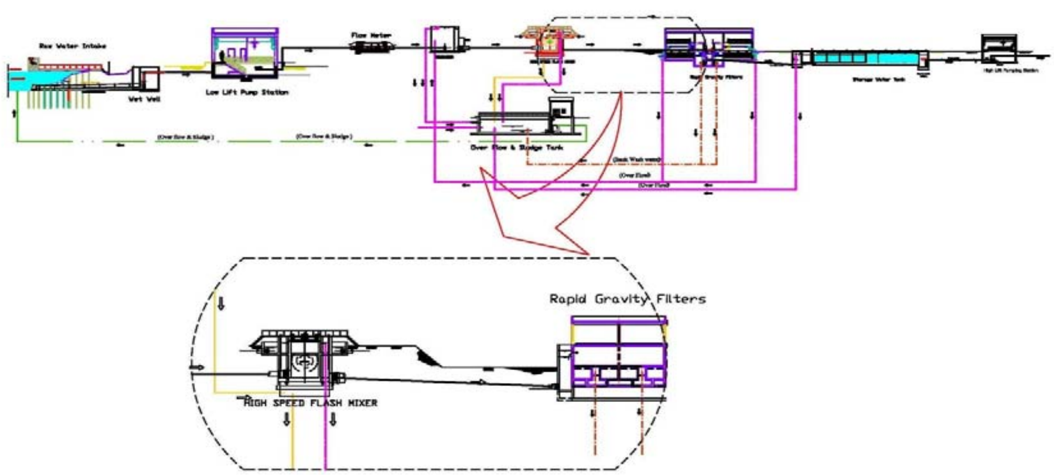
Traditional water Treatment pant Hydraulic Profile -Using Pressure Filters



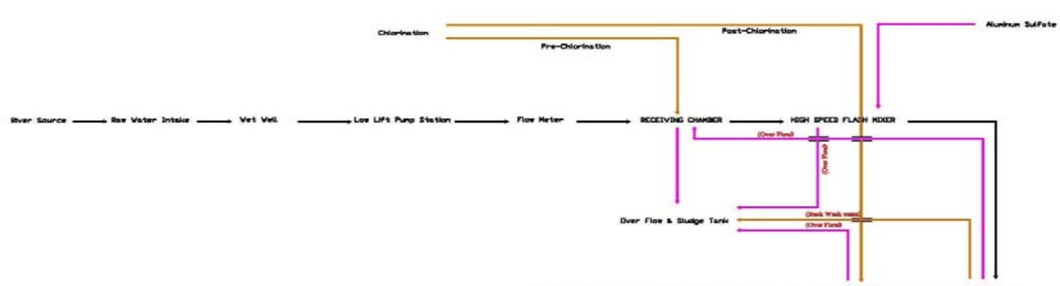
Traditional water Treatment pant Flow Diagram - Using Pressure Filters

In typical direction filtration operations, coagulants bearing a cationic charge are most often used. Polymers are accepted by the US Environmental protection Agency (EPA) and Public health & Safety Organization (NSF) for use in potable water.

The major difference between conventional traditional treatment plant and direct filtration is the absence of a separation process, such as sedimentation or flotation, between coagulant addition and filtration. Direct filtration can be preceded by preoxidation, may be accompanied by Powdered Activated Carbon (PAC) addition, and in some cases followed by Granular Activated Carbon (GAC) adsorption.

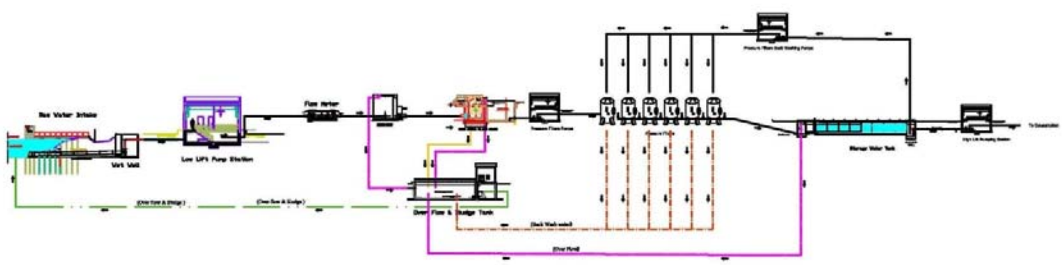


Direct Filtration Hydraulic profile - Using Rapid Gravity Filters

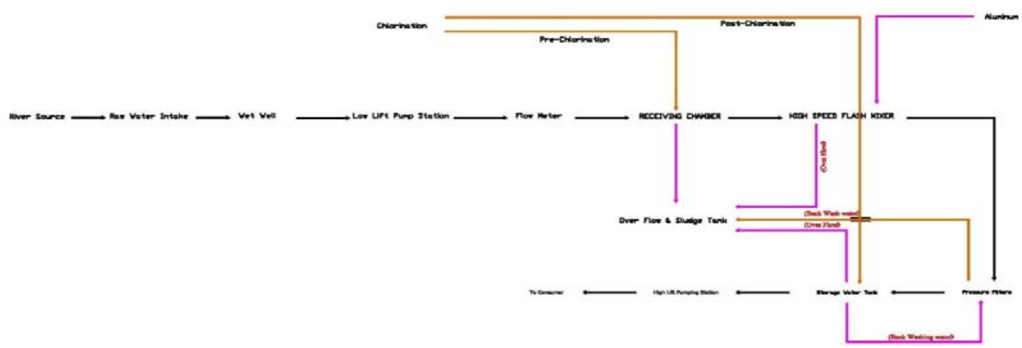


Direct Filtration Flow Diagram - Using Rapid Gravity Filtration

The same basic general physical chemical principles described in conventional treatment apply to direct filtration. Low coagulant dosages and high-intensity, short duration flocculation in a tank or in the media pores are used in direct filtration to promote the formation of a pinpoint sized floc which can penetrate the filter depth maximizing the filter beds storage capacity.



Direct Filtration Hydraulic profile - Using Pressure Filters



Direct Filtration Flow Diagram - Using Reassure Filters

Direct filtration(DF) has several advantages compared to conventional treatment: (1) lower chemical costs due to lower coagulant dosages used in direct filtration, (2) lower capital costs as the sedimentation (and sometimes the flocculation) tank is not needed, and (3) lower operation and maintenance costs as the sedimentation (and sometimes the flocculation) tank need not to be powered or maintained.

There are also disadvantages to direct filtration, including: (1) it cannot handle water supplies that are high in turbidity and/or color, (2) short response time for operators to adjust treatment to changes in source water quality, and (3) less detention time for controlling seasonal taste and odor problems.

Water quality parameters such as pH, temperature, and alkalinity may dictate effectiveness of direct filtration. The pH affects the speciation of the coagulant as well as its solubility, the speciation of the contaminants, and the filterability of particles.

Temperature also impacts the process because it affects the viscosity of the water. At lower temperature waters can decrease the hydrolysis and precipitation kinetics. Some of the alternative coagulants such as poly-aluminum chloride can be advantageous over the traditional aluminum and iron salts in low temperature conditions as these coagulants are already hydrolyzed, and therefore temperature tends to have less effect on the coagulation process.

III. Water Purification

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 fertilizers.

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.

IV. 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,
- 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.

V. Effect of Filter Depth on the Removal Efficiency

It is will known that, the filter depth has a direct relation with the filter efficiency, i.e., increasing the filter depth will increase the filter efficiency. In the present case, Fig. (2) shows the effect of filter depth on the removal efficiency of the direct filter. The new investigation of the present case is that, 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 drastic increase is observed in the filter efficiency. For filter depth more than 0.8 m, moderate increase is observed in the removal efficiency. From Fig. (2), it is clear that the removal efficiency may reach 99.0 % when the filter depth reaches 1.2m according to the running conditions. From which, the maximum depth was taken as 1.25 m. With more increase in the filter depth, insignificant increase is obtained in the filter efficiency. At the optimum conditions of particle size, alum dose of 35.0 mg/L (liquid alum with 27 % conc.), run time of 20 hr, surface loading of 3.5 m/hr and temperature of 32 C^{o}.

VI. Effect of Surface Loading on the Removal Efficiency

Surface loading slowly affect the removal efficiency when filtration rate is less than 4 m3/m2/h. Increasing the surface loading up to 12 m3/m2/hr, the removal efficiency reaches to 23 %. With more increase in water level, the removal efficiency comes down to less than 57%. At the optimum conditions of particle size of 4 mm, alum dose of 35.0 mg/L, run time of 20 hr, filter depth of 1.25 m and temperature of 32°C,

VII. Effect of Particle Size of the Media on the Removal Efficiency

The particle size of the media plays the most important role on the filter efficiency. As found in many literatures, Chuang and Kun-Yan Li (1997) have confirmed that, there exist a high the effect of grain size on the performance of direct filtration. The removal efficiency comes down to insignificant value at using particle of size 50 mm for the filter. In practice the particle size of 3-5 mm is recommended. However, at some cases of pre-treatment work, particle size greater than 5 mm may be of use. At the optimum condition of alum dose of 15 mg/L, filter depth of 0.40 m, surface loading of 5.0 m/hr, run time of 8-20 hr ..etc,

VIII. Effect of Alum Dose Concentration on the Removal Efficiency

Several factors may Govern the optimum dose of alum such as, turbidity level of raw water, surface loading, ... etc. Chuang and Li (1997) have studied the effect of coagulant dosage on the performance of direct filtration; they stated that, there exists an optimum dose at which the filter produces high effluent efficiency.

IX. Effect of Run Length on the Removal Efficiency

The other factor, which affects on the filter efficiency, is the running time relative to the beginning and the end of the washing time. When the run time is done after the washing immediately, low level efficiency is obtained. On the other hand, if the run time is conducted just before the washing time, high level efficiency is obtained.

X. Physical Properties of Direct Filtration

Because the type of flocculation process typically used in direct filtration is not as efficient as conventional treatment in forming floc, variable water turbidity and bacterial levels constitute problems for maintaining good filter effluent quality. Thus, direct filtration is primarily used only for the treatment of good quality sources characterized by turbidity of less than 10 to 1 NTU, & color of less than 20 to 40 units, and low concentrations of algae iron and manganese. For water supplies that are consistently very low in turbidity and color, the flocculation tank is sometimes omitted and the process is then referred to as in-line filtration.

XI. Mechanical of Filtration

Filtration depend mainly on kind of particles, and the filter media. In general factors affect the filtration are:-

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 wave forces,

Global Journal of Researches in Engineering (E) Volume XIV Issue II Version I Year 2014

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.

3rd – detachment mechanism, as part of above forces and particles being catch either over the surface

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.

3rd – 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,

Turbidity Injection

To solve above we can do either

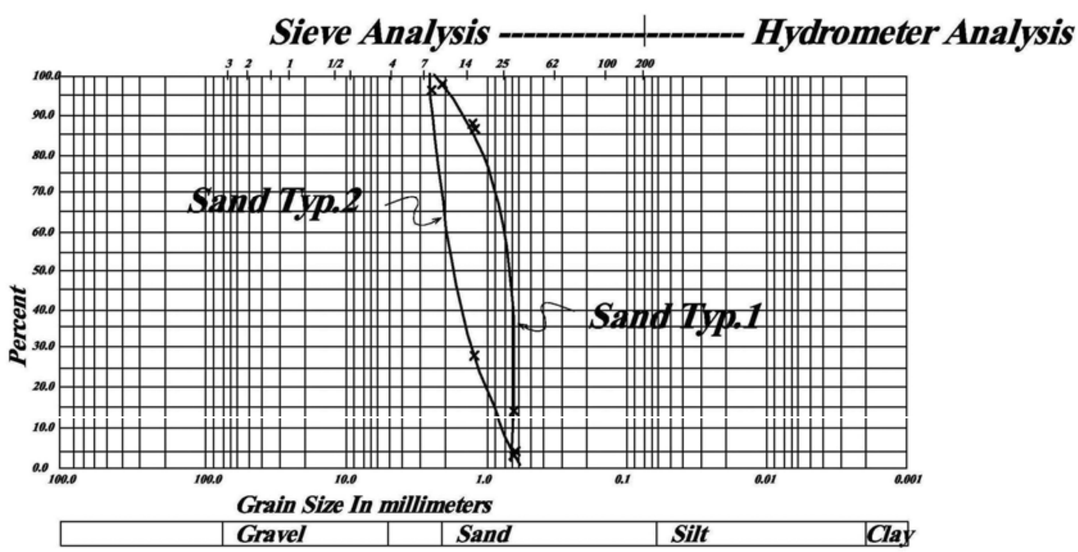
1st – increase particles size inside the media be injecting polymers inside the filter.

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

3rd – Reduce filtration rate. Inside each layer. Which can be done using radial filtration?

XII. Laboratory Experiment

Works and test first made in the laboratory using filtration Plexiglas tube inside Dia.21cm, height 280 cm, there are some gates on levels 75cm, 125cm, 280cm, to easy excess to filtration media, as per attached fig. the turbidity was controlled by dosing the Rate Via apartment also the coagulant dosage, then coagulation and flocculation using spiral tubes,

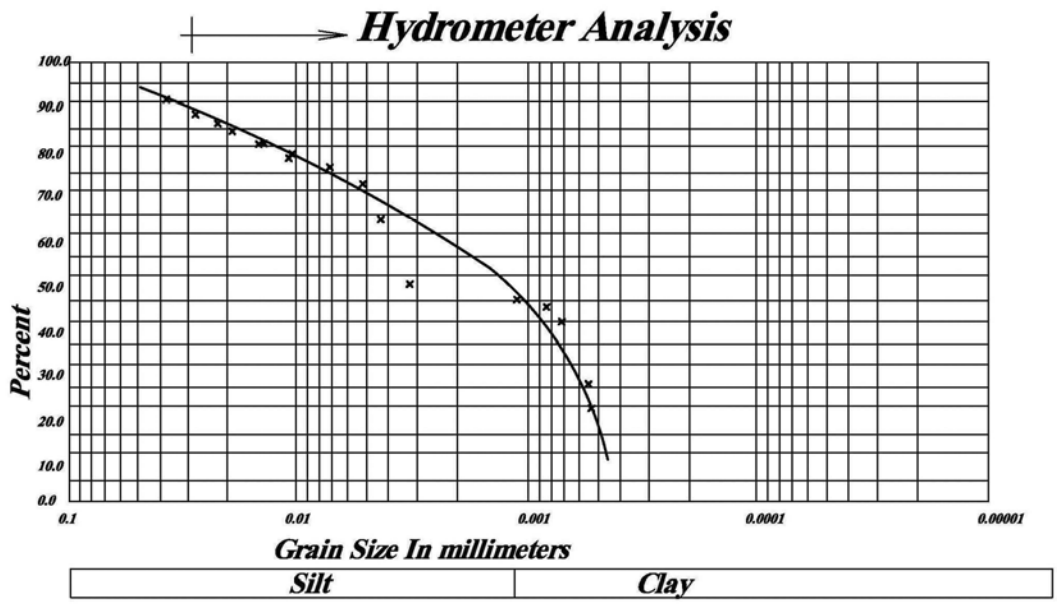


Sieve Analysis for Filter Sand (USED)

Sieve Analysis For Filter Sand (Used)

Specification Material	coefficients of permeability cm/sec	density gm/cm3	porosity %	specific weight G	D10	D16	D50	D60	Effective Size (E)	Coefficient of non uniformity (U)	Geometric mean size (Mg)	Geometric standard deviation
Sand Typ.1	0.205	1.775	30.799	2.565	0.6	0.58	0.65	0.7	0.6	1.1666	0.65	1.1206
Sand Typ.2	0.445	1.569	37.506	2.511	0.75	0.9	1.8	2	0.75	2.6666	1.8	2
Crashed Brick Typ.1	8.78	1.072	55.72	2.421	4.5	4.8	7	8	4.5	1.77	7	1.4583
Crashed Brick Typ.2	4.155	1.145	52.705	2.421	2.9	3	3.5	4	2	1.379	3.5	1.1666
Sand (1+2) (1:1)	0.553	1.531	40.56	2.576								

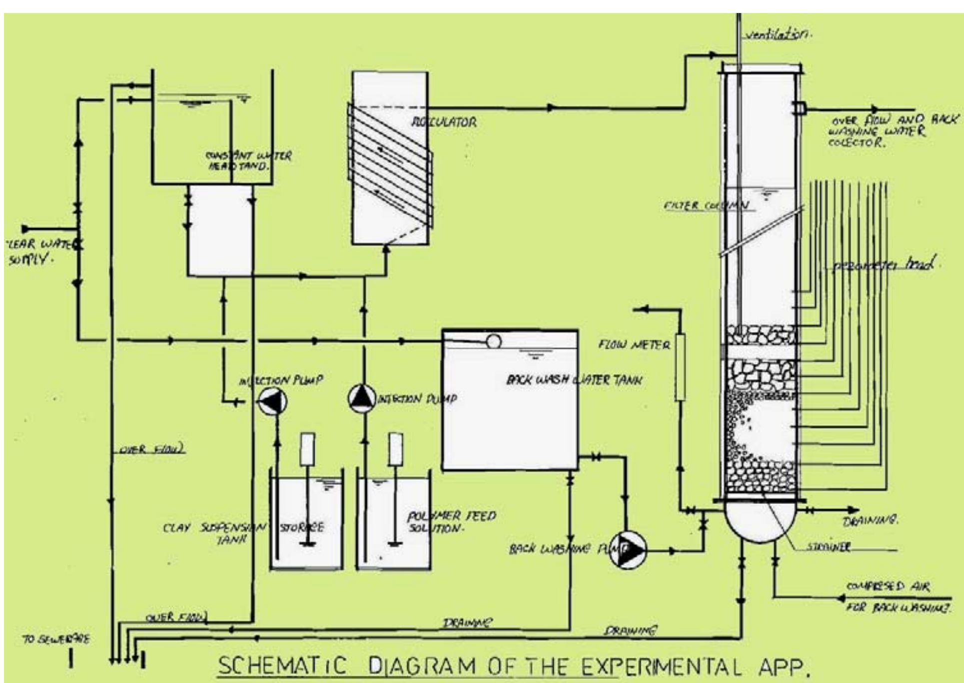
The turbidity in laboratory test was produced and controlled within the experimental test using fine mud (kaolin) mixed with very clear water with dosage and pumped to coagulation system Via prelistatic pump. Our laboratory turbidity calculation was done using RALANGE-LTP.5 using FTU Units, that are why we have first to make calibration for the Dosage of Kaolin and the turbidity calculation apparatus.



Sieve Analysis for the Turbidity Used In The Tests

a) Unit Operation

All the experimental test was done using variable filtration Rate, in which water Rise during filtration cycle as the filtration increase in its losses due to continues separation of Turbidity within filter media and cake deposit on filter surface.



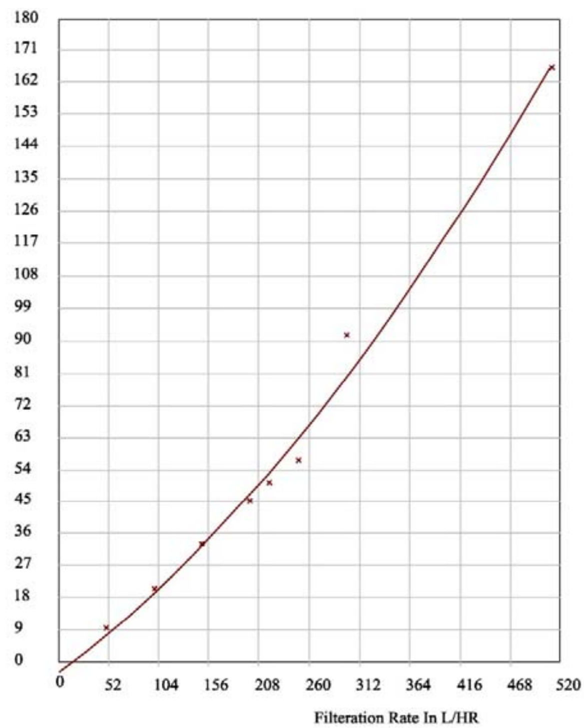
SCHEMATIC DIAGRAM OF THE EXPERIMENTAL APP.

b) Filtration Media

Sand filtration used within experimental tests either within single media filter or multimedia filtration can be seen in fig. also some new filtration media is proposed as first layer using crashed Brick after sieving also can be seen within fig. attached all those media layers was distributed over aggregate layer with particles 0.8-to 1.0 cm Dia.

c) Experimental Test

About 70 laboratory test was conducted using deferent dosage, and different media layers, and different type & dosage of coagulant,



The Value Of (G) With Filteration Rate for This Study

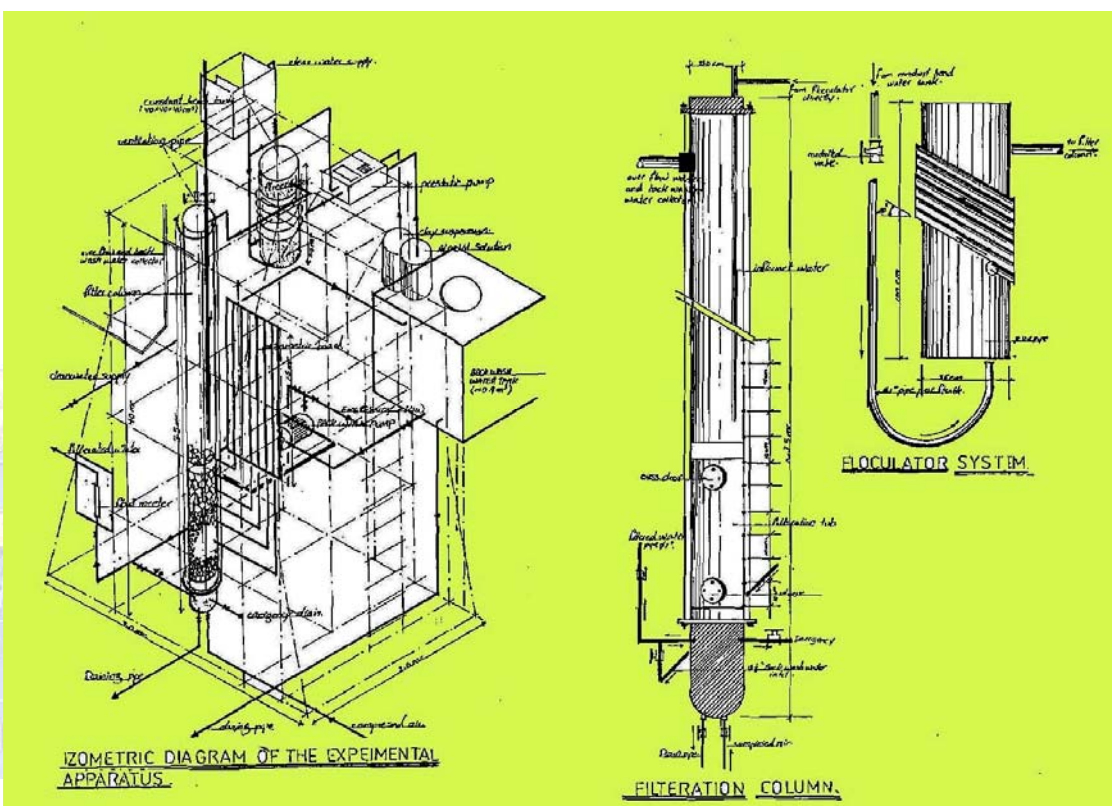
d) Experimental Results

Results of above showed that:-

- 1st – 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.
- 2nd – it is possible to use crushed brick, stone or Aggregate (20to50mm) as first layer, in addition to the sand layer,
- 3rd - increase filtration efficiency up to 98%.

e) Laboratory Test

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.



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Parameters used to characterize the direct filtration process include filter loading rate, filter run time, filter media, and head loss. Typical direct filtration loading rates range from 2 to 10 m3/m2/hr; however, filter loading rates greater than 10 m3/m2/hr have been used in some places (but no records was foreseen). This can be a critical parameter because it determines the water velocity through the filter bed can impact the depth to which particles pass through the media. The filter run time describes the length of time between filter backwashes during which a filter is in production mode.. As the filter run time increases and the concentration of solids in the media increases, the filtration process often performs better with regard to particulate contaminant removal. Head loss is the pressure drop that occurs when water flow through the filter media. Its development during the filtration run gives an indication of how quickly the filter is approaching the terminal head loss and the end of the run.

Residuals generated by the direct filtration process include coagulation solids (sludge) and spent backwash (BW). The amount of residuals that is generated in direct filtration (DF) is significantly less than in conventional treatment. This is a consequence of the lower coagulant dosages that are used in direct filtration (DF).

f) Iraqi Artificial Lakes and Dam lakes

Iraq considered one of the rich countries in water recourses as there are artificial water lakes distributed at different location of the country in addition to many Dams lake and water control project providing Artificial Lakes , As the mains water recourses are tigers & Euphrates Rivers, both are with good water quality with Turbidity that Rises' during flood seasons, This turbidity needs to be removed in water treatment plants by both physical and chemical methods, Lakes changes in raw water quality. Long detention times resulted in lower turbidity where clearer water favored increased growth of phytoplankton.

Summary Data for Important Lakes In Iraq

No.	Name	Length In Km.	Width in Km.	App.Area In Km2	App.Parametars in Km	Remarks
1	Tharthar Lake	71.25	6.18 to 30.07	1,499.62	382.50	Refer To Fig.s No.1,2,3,4
2	Razazza Lake	27.47	2.23 to 9.64	141.80	124.96	Water Surface Area could be Extend to 1,810 Km2 During Flood , Lake Volume of Water Reserved Up to 26,000,000,000 m3, can be considered the 2nd Biggest water Lake in Iraq. Refer To Fig.s No.1,3,5,7
3	Habbaniyah lake	27.30	9.00 to 18.00	261.00	86.83	Refer To Fig.s No.1,6,7
4	Mousul Dam Lake	48.52	6.00 to 12.00	239.39	223.52	Refer To Fig.s No.1,8,9
5	Darbandikhan Lake	59.64	9.59 to 37.94	391.72	473.79	Refer To Fig.s No.1,10,11
6	Dukan Lake	27.36	2.87 to 17.62	155.21	117.11	Refer To Fig.s No.1,12,13
7	Almamlaha Lake	57.44	1.76 to 12.72	463.84	22.45	located south of Basra city ,far South of Iraq, very salted Water, with high concentration of Mgo.could not be user for Drinking ,Refer To Fig.s No.1,14
8	Al-Qadisiyah Dam Lake	52.94	7.43 to 17.54	556.04	176.74	Refer To Fig.s No.1,15
9	Chebayish Lake	77.71	10.08 to 38.04	1,460.87	458.72	Refer To Fig.s No.1,16,17
10	Amara Ahwar	77.96	7.65 to 32.03	1,496.90	290.70	Area(Inside Iraq)=1058.61 Km2,Parameter (Inside Iraq) =261.90 Km, Refer To Fig.s No.1,18
11	Anah Lake	35.36	5.97 to 16.76	336.57	270.38	Refer To Fig.s No.1,19,20
12	Hammar Lake	25.25	4.31 to 9.31	151.51	96.61	Refer To Fig.s No.1,21
13	Sawa Lake	4.40	0.73 to 1.83	4.70	11.71	Refer To Fig.s No.1,22

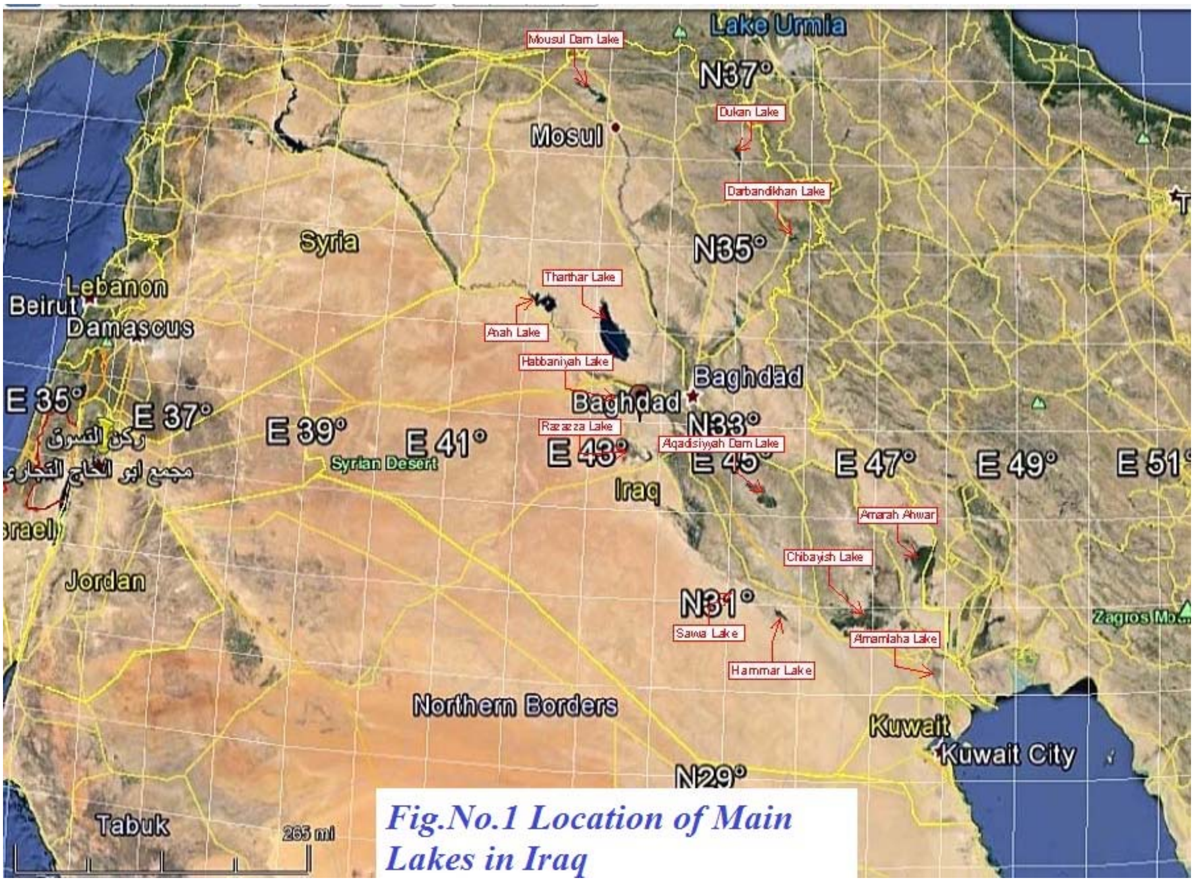

Fig.No.1 Location of Main Lakes in Iraq

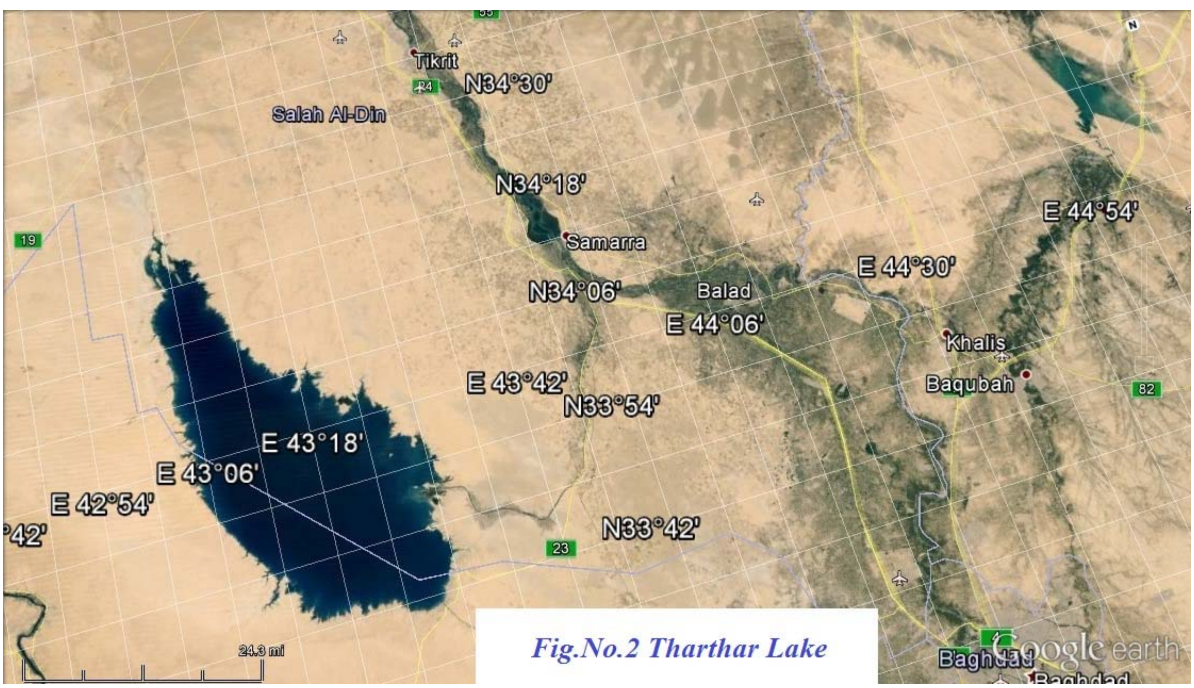

Fig.No.2 Tharthar Lake

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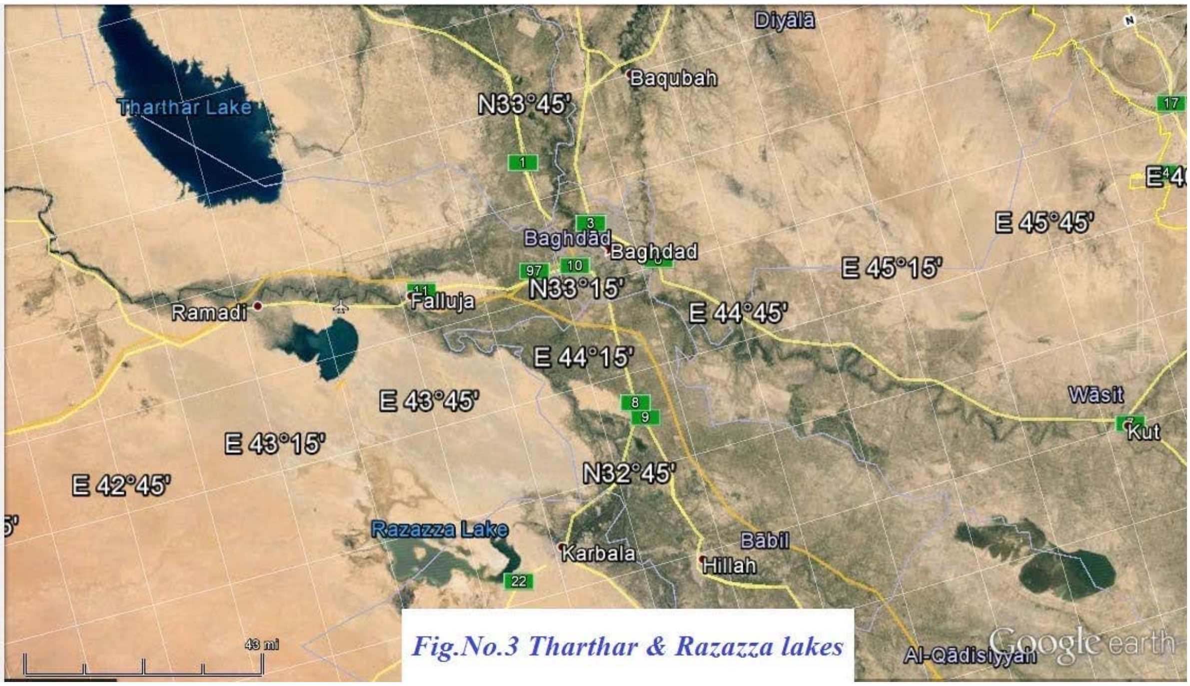

Fig.No.3 Tharthar & Razazza lakes

Fig.No.4 Tharthar Dam

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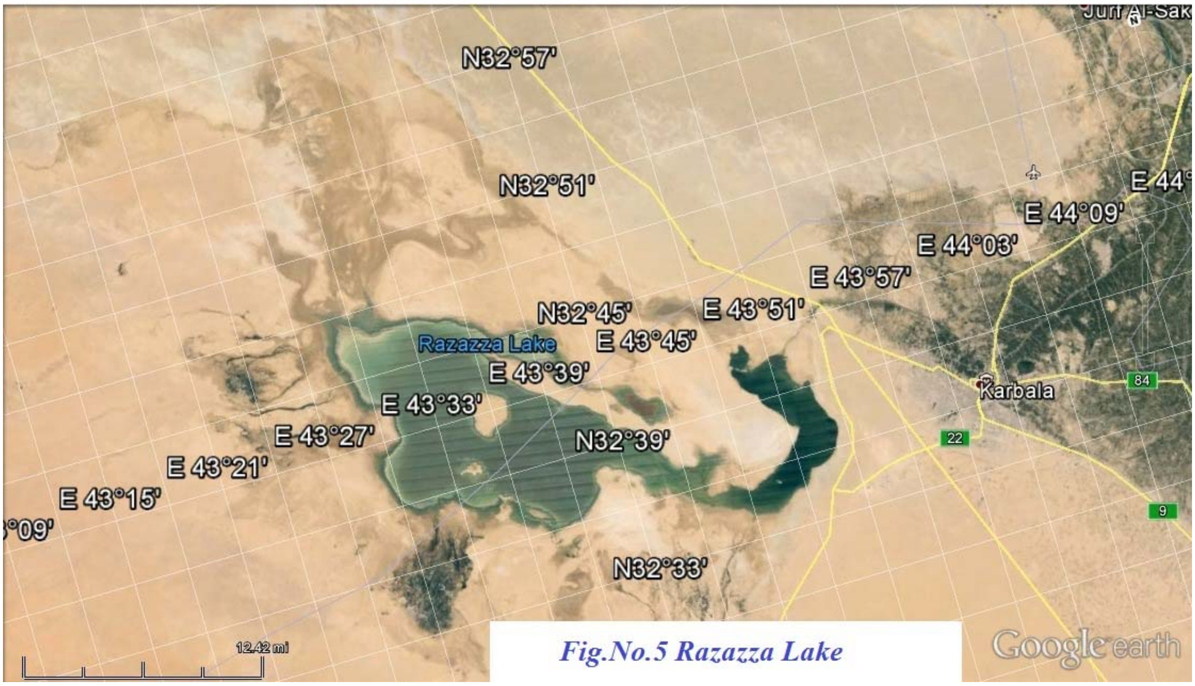

Fig.No.5 Razazza Lake

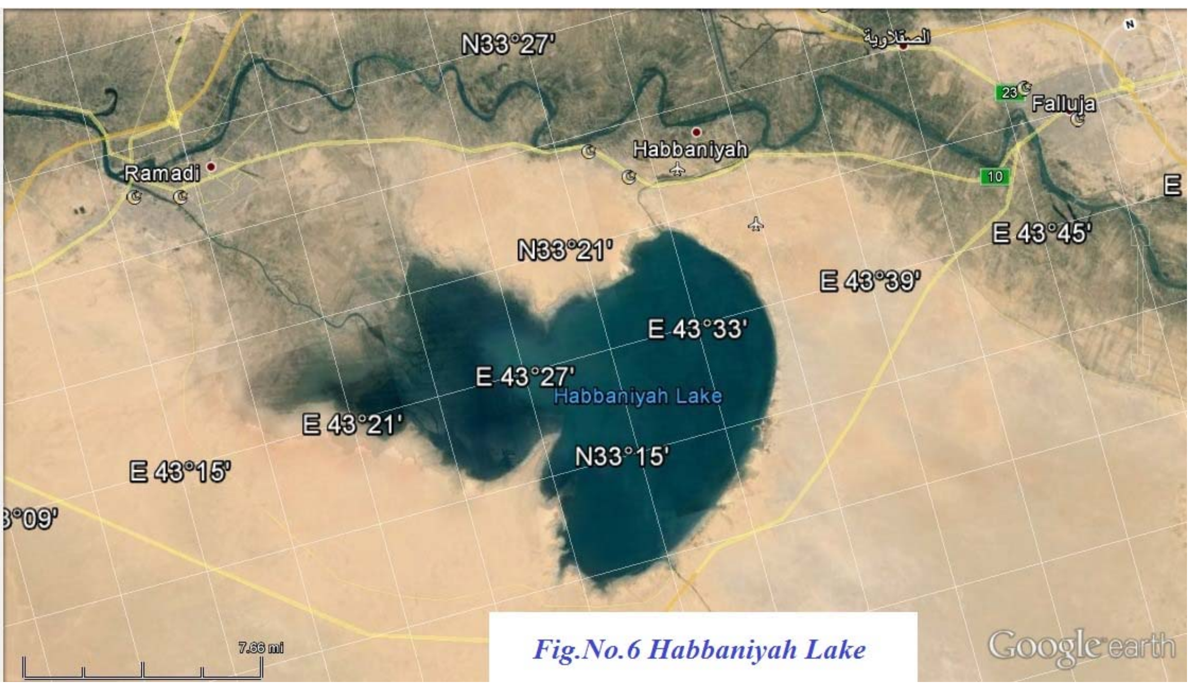

Fig.No.6 Habbaniyah Lake

Fig.No.7 Habbaniyah & Razazza Lake

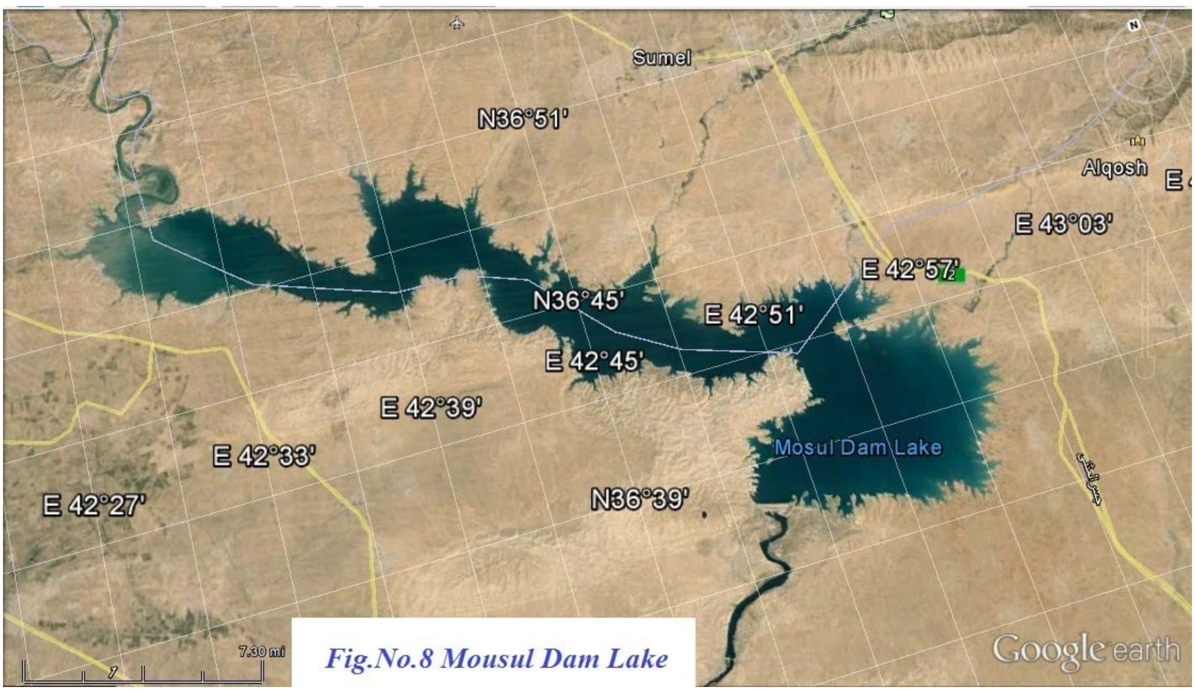

Fig.No.8 Mousul Dam Lake

Fig.No.9 Mousul Dam

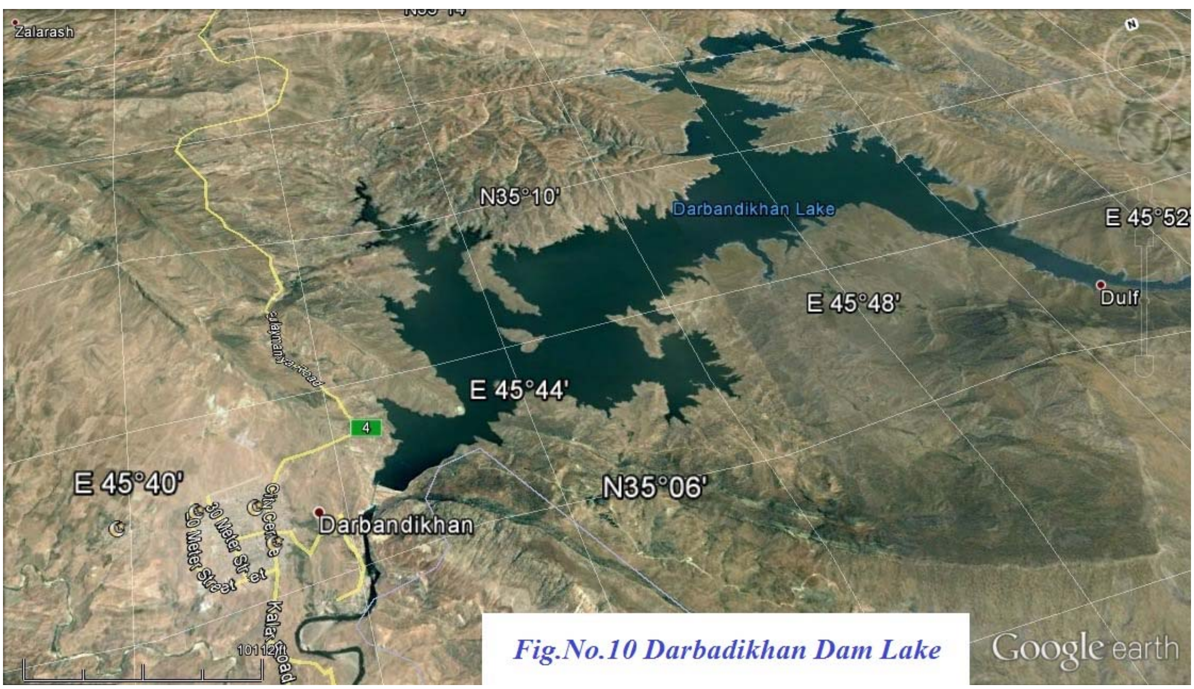

Fig.No.10 Darbadikhan Dam Lake

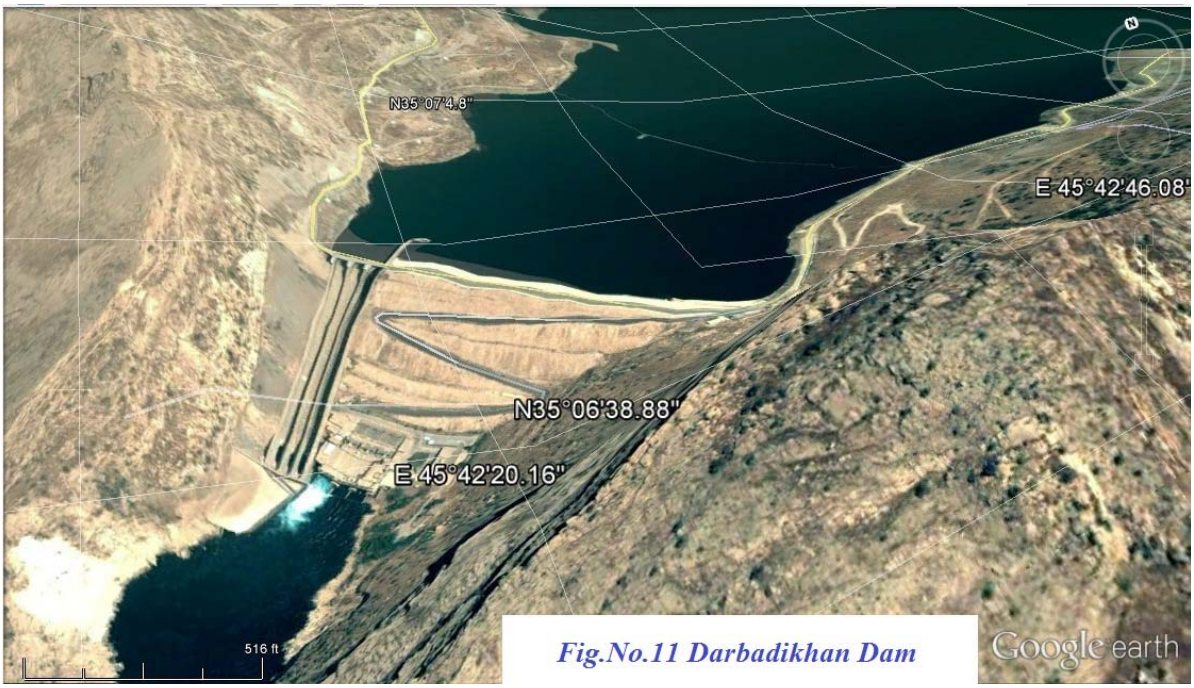

Fig.No.11 Darbadikhan Dam

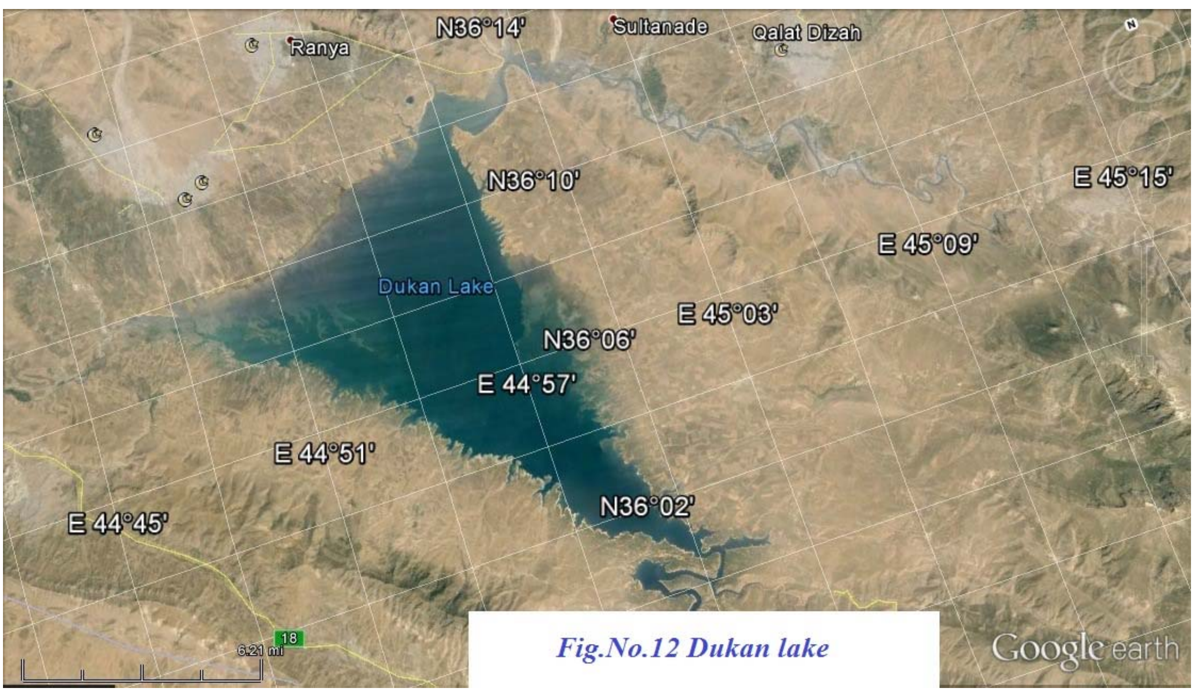

Fig.No.12 Dukan lake

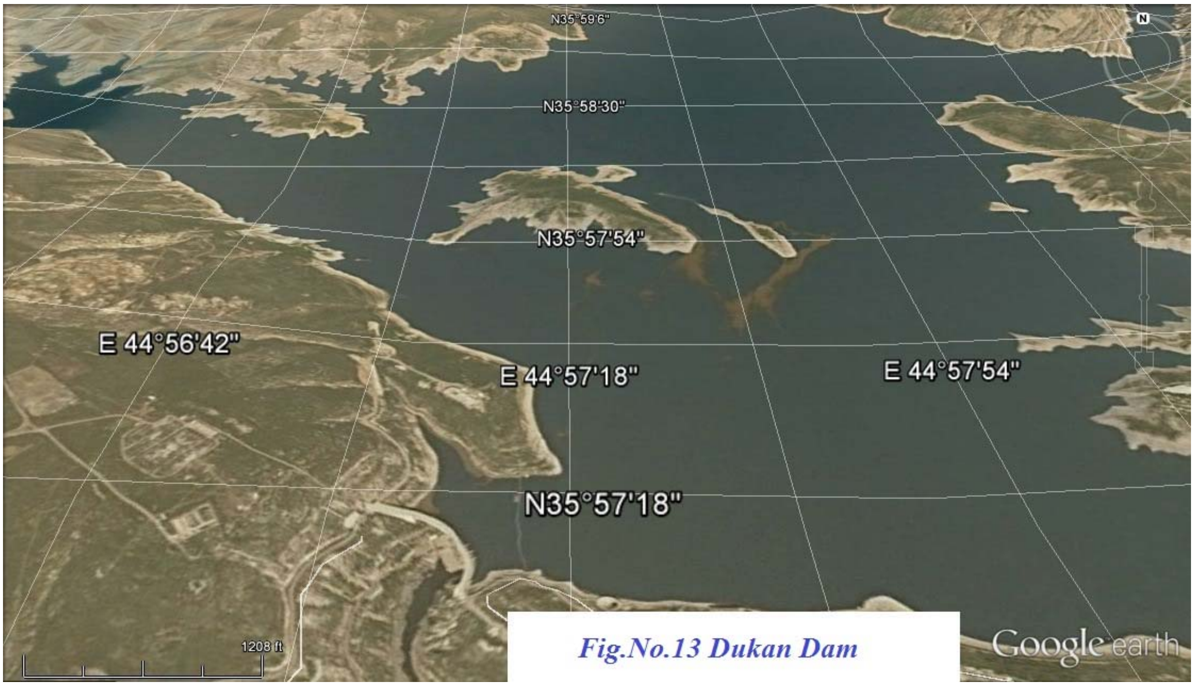

Fig.No.13 Dukan Dam

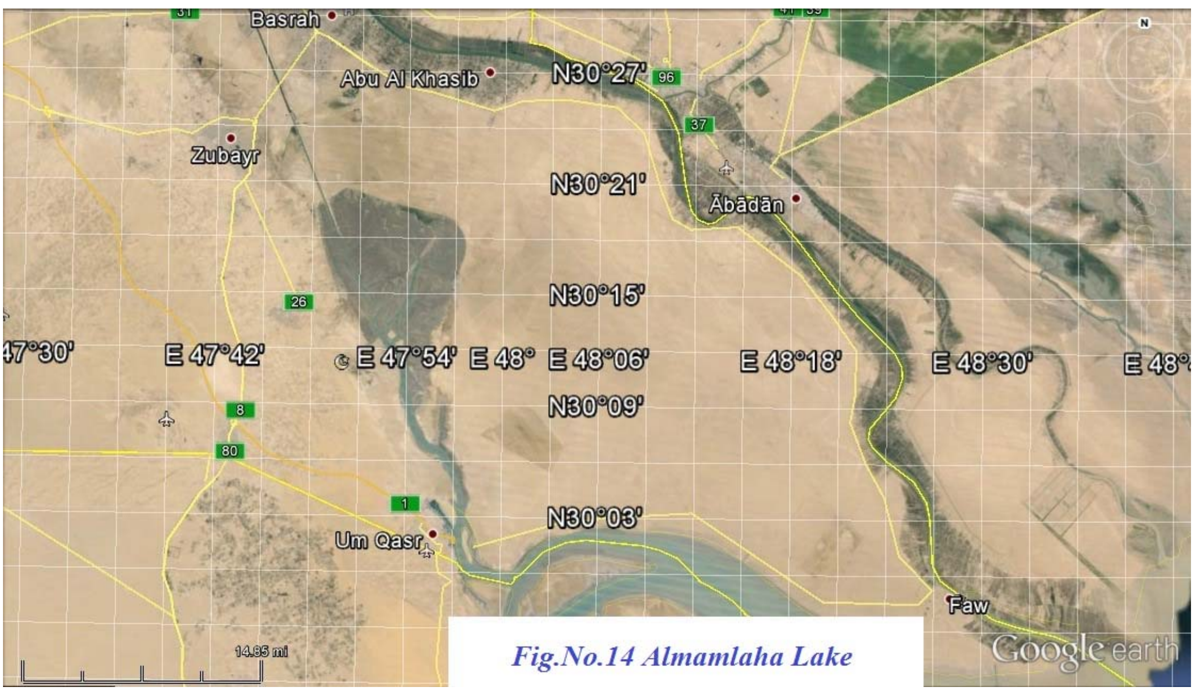

Fig.No.14 Almamlaha Lake

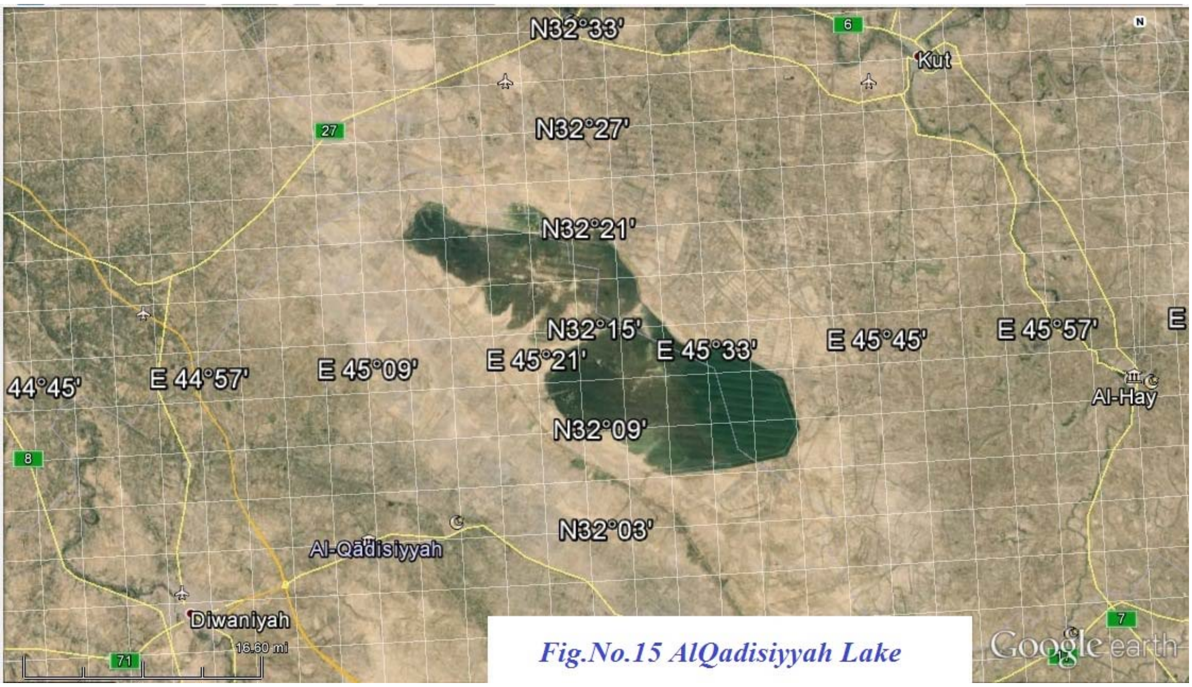

Fig.No.15 AlQadisiyyah Lake

The construction of many High water Dams in Iraq led to the formation of Natural/or Artificial Lakes normally extending over a huge area that trapped large amounts of Turbidity. Lakes and reservoirs 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 reservoirs or 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.

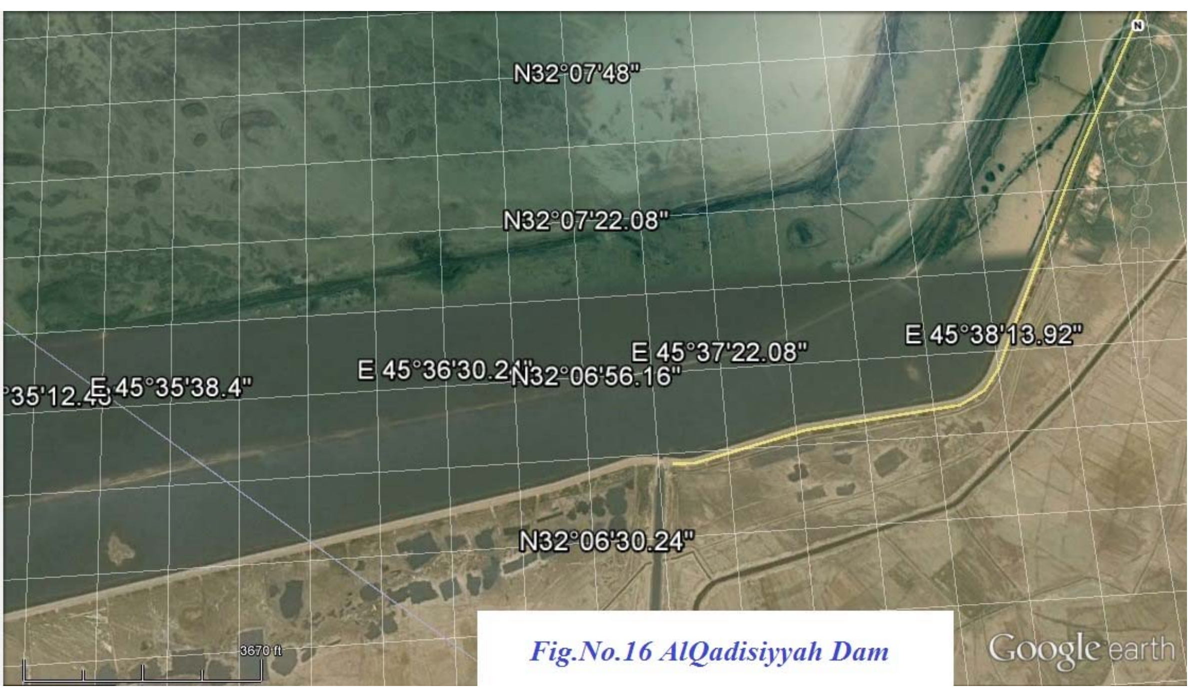

Fig.No.16 AlQadisiyyah Dam

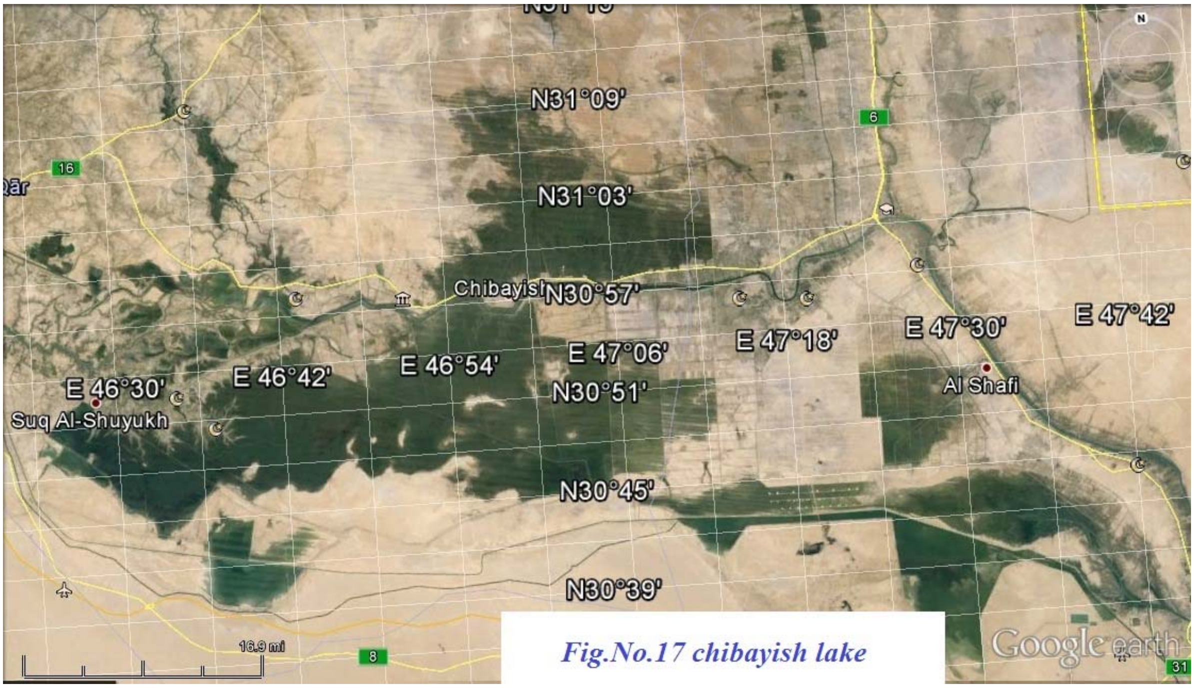

Fig.No.17 chibayish lake

Fig.No.18 Amarah Ahwar

Many microorganisms commonly found in source waters do not pose health risk to humans, others such as Cryptosporidium and Giardia can be sources of infectious and communicable diseases that can resist chlorine disinfection,

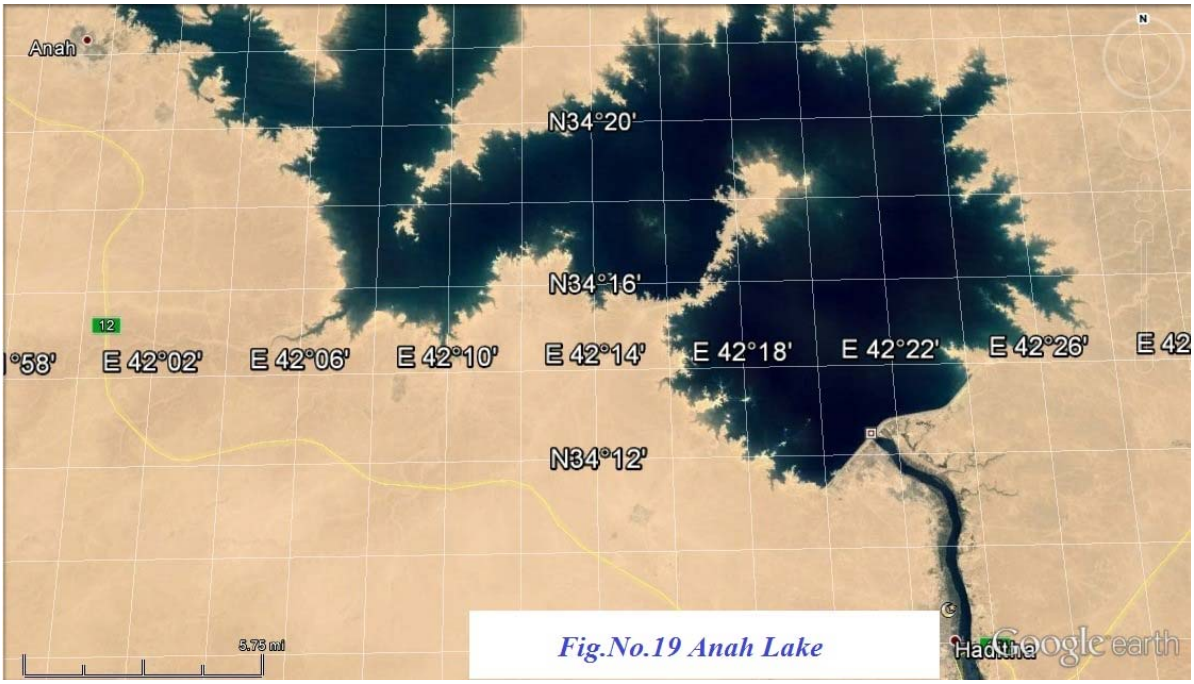

Fig.No.19 Anah Lake

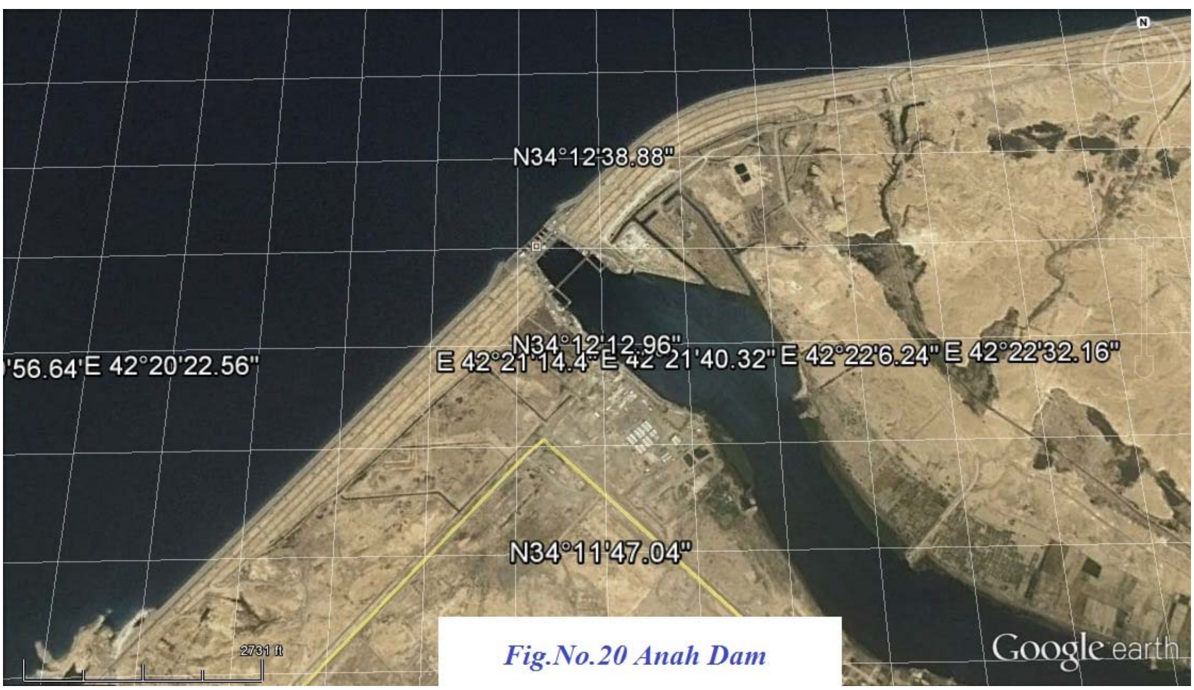

Fig.No.20 Anah Dam

From Above it is clearly understand that 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,

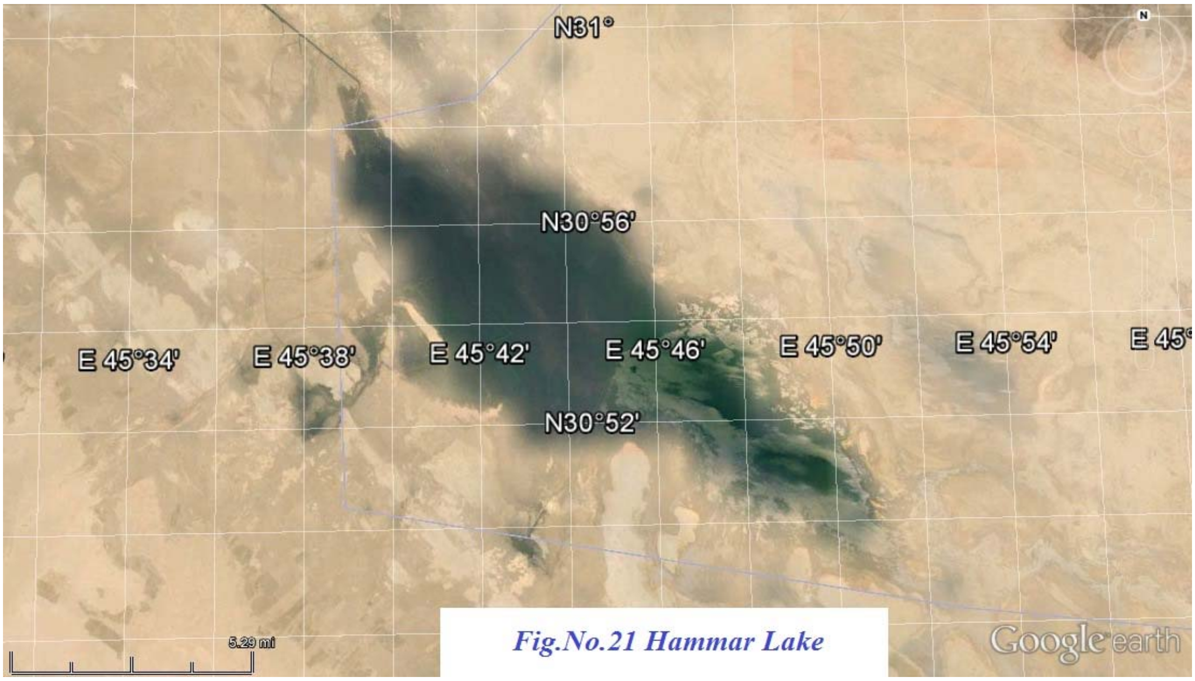

Fig.No.21 Hammar Lake

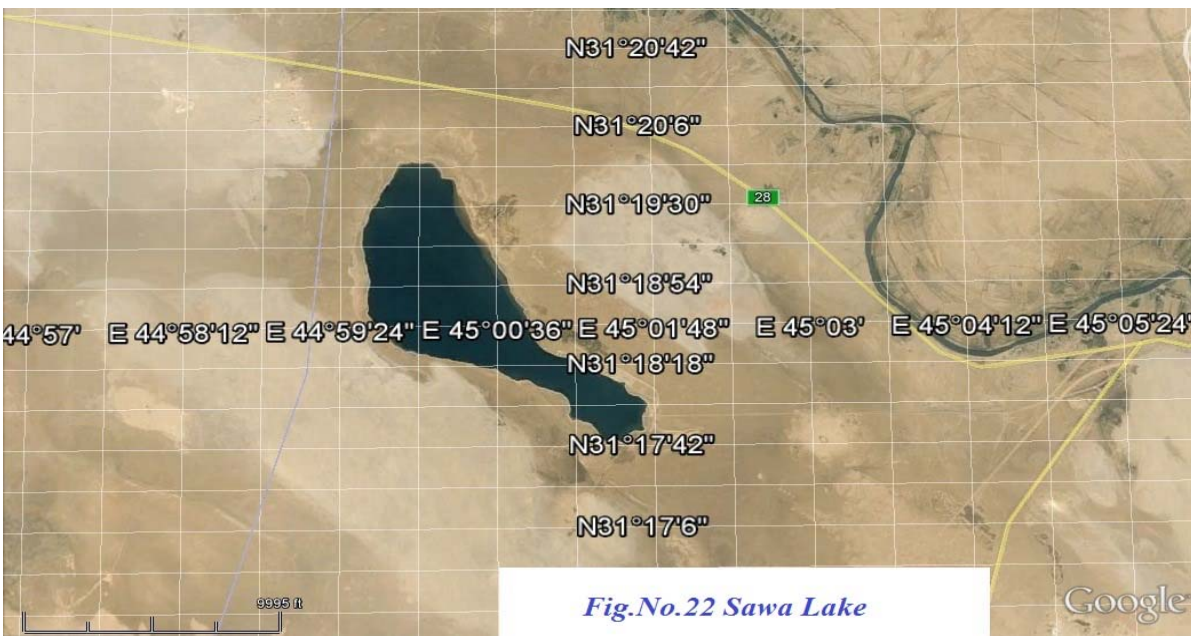

Fig.No.22 Sawa Lake

g) Lakes Turbidity

All records for more than 40 years shows that all the Iraqi lakes either natural lakes or artificial ,have very low concentration of Turbidity which ranges between 0.5 FTU Up To 10.0 FTU, and some times During Flood seasons could Rise up to 10FTU, in the other Side the TDS Ranges from 100mg/l (or even Less) Up to 10,000 mg/l for natural lakes such like chibayishlake, Amarh ahwar, Almamlaha Lake, This Rising concentration makes the water of those Lakes undrinkable, and the Purification needs for such lakes water needs more than the Removal of Turbidity, those further treatment is suggested such as Reverse Osmoses ,Or Ultra filtration system, or use of Menrlization plants for further Removal of TDS.

XIII. Tests Conclusions

It can be concluded from above discussion the following:-

- 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.
- Almost all Lakes have low Turbidity Concentration Due to long detention time, which acts like preliminary Artificial Settling tanks.(logon).
- Increase filtration efficiency up to 98%.
- Some of the artificial lakes in Iraq have high TDS Concentration which really makes the water

undrinkable. And need Further Treatment to Reduce the Salinity concentration.

- Water quality parameters such as pH, temperature, and alkalinity may dictate effectiveness of direct filtration. The pH affects the speciation of the coagulant as well as its solubility,

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