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EFFECT OF FLOW RATE AND SUSPENDED SOLIDS ON CLOGGING OF RECHARGE WELLS IN DIFFERENT SOIL TYPES

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ملخص البحث :

تعتبر آبار الشحن من أهم المصادر المستخدمة في عمليات تخزين المياه بطبقات التربة الغير منفذة، وأثناء تلك العملية تتعرض آبار الشحن للعديد من المشاكل الكيميائية والفيزيائية والبيوكيميائية، وتعتبر مشكلة إنسداد الآبار أثناء التشغيل بسبب تراكم المواد الصلبة الموجودة بالمياه في الفراغات البينية للتربة من أهم المشكلات الفيزيائية الموجودة بآبار الشحن.

وقد تم عمل التجارب فى معمل الهيدروليكا والري بكلية الهندسة -جامعة الأزهر- القاهرة .حيث يتكون النموذج المعملي من ثلاثة خزانات لهما نفس القطر والإرتفاع 52 سم و 85 سم علي التوالي، بحيث كان إرتفاع المياه 1.20 م من أعلي فتحات التثقيب بالبئر وتم تغير إرتفاع المياه إلي 1.35 م ثم 1.50 م،المياه المغذية للبئر تم خلطها بمواد صلبة لها عدة تركيزات مختلفة من المواد الصلبة .ثم تم أخذ قياسات معدلات التدفق الخارجة من البئر وتم عرضها في جداول ومنحنيات وتم تحليل النتائج ومناقشتها والتي تبين منها أن إنسداد آبار الشحن يعتمد علي عاملين مهمين الأول هو معدل التدفق والذي يتحكم به هو ارتفاع منسوب المياه المشحونة والثاني هو معدل تركيز المواد الصلبة الذائبة في مياه الشحن حيث وجد أنه كلما حدث تغيير في كفاءة البئر فإن التغيير في ارتفاع منسوب المياه يؤثر علي التغيير في كفاءة البئر بنسبة 20% :31 % ، والتغيير في تركيز المواد الصلبة يعمل علي تغيير كفاءة البئر من 70 % إلي 80% بحيث أنه كلما زاد إرتفاع منسوب المياه وزادت معه تركيز المواد الصلبة فإن ذلك يعمل علي تقليل معدل التدفق الخارج من البئر مع مرور الزمن، وإعتمادا علي تلك النتائج فإنه يوصي لعملية الشحن في التربة الرملية فإنه يجب إستخدام نوعية تربة ذات جزيئات بينية كبيرة حيث تعطي أفضل معدل تدفق ناتج من البئر مع مرور الزمن.

ABSTRACT

A recharge wells is considered a very important source of water storage in confined layer soil, of which recharge well will be clogged due to many different sources, chemicals, physical and biochemical sources. Total suspended solids have a big effect on a physical clogging.The experiments were performed in the hydraulic laboratory of the Faculty of Engineering, Al-Azhar University. The model consist of three tanks with same dimension 0.52 m diameter, 0.85 m height. Water head was 1.20 m from well perforation and be changed to 1.35 m and 1.50 m, and water fed well mixing with different concentration of total suspended solids. Measurements were undertaken and presented in tables and figures. The results were analyzed and discussed from which it was clear that the clogging well due to total suspended solids depend on two parameters; the first is the flow rate, through which water head, and the second is the concentration of total suspended solids.When a change occurs in the efficiency of well in sandy soil, change in water head affects the efficiency from 20% to 31% and change in the concentration of total suspended solids affects the efficiency from 70 % to 80%. If water head is increased and concentration of suspended solids also be increased, this results in the flow rate out from well will decrease by the time. Depending on these results, it was recommended to recharge in sandy soil with big voids with small concentration of total suspended solids to get better flow in better time.

Keywords: Recharge Well, Suspended Solids, Clogging.

1. Introduction

Ground water, in many countries of the world, is the main source of water supply. However, it is limited and due to the excessive withdrawal from the underground aquifers, problems like salinity**[1]** , land subsidence results, the cost of pumping water, and treatment of the water which extracted from the underground aquifers and wastewater disposal**[2]**. These problems make us turn to another way to find an easy source of water that can overcome some of these problems. Thus, this directed attention to the recharge from any source such as agriculture drainage and by any surface water to recharge it by well with small diameter to underground basin, canals or natural confined aquifer. We can re-use this water by using many ways like immediate dewatering this water by pumps or storing it in natural basin or industrial basin. But through this process, we can find a lot of problems in general as clogging of well and the process of recharging will be stopped and the well will not give us the flow out which we need and this will cause losing of a lot of natural water, surface water and underground water.

This research studies the effect of total suspended solid on clogging of the recharge well, which belongs to physical clogging **[3]**. The flow rate that get out from the well will be measured in this study along with drawing of many curves that explain the decrease of flow rate and the time that well will take to be clogged will be measured. This is can be done through different types of soil like sandy soil. Therefore, we should know the suitable time nessasry for well before clogging, effect of water head, total suspended solids on clogging of the well and amount of total suspended solids in the water recharge to avoid this clogging by any way like what will be explained in this research.

Studying the most common cause of physical clogging of recharge wells occurs when suspended solids are filtered out of injected water by the aquifer material. Thus, physical clogging is primarily influenced by water quality, and more specifically such like the shape, size, composition and concentration of particles in recharge water, Particle filtration can lead to reduce the hydraulic conductivity of the soil, and also the water bubbles which occur when water fall down inside the well from large height, temperature of water have an effective role of clogging well and the velocity of flow rate which carried a lot of particles from the land **[4]**.

Causing and prevention of well bore clogging by particles Well clogging is defined as a decrease in the specific capacity (= volume flow, Q in m3/h, over drawdown, Δs in m) over time **[5]**.

2. Theoretical Approach

In the context of determining the most clogging of the recharge well device, a theoretical approach was chosen. Moreover, a set of statements or principles (devised to explain a group of facts or parameters that are repeatedly tested or widely accepted and can be used to make predictions) about the relationships between parameters, was suggested to explain the principles and methods of analysis. In this study, the theoretical approach, that was chosen to be implemented, is based on the dimensional analysis theory and similarity.

2.1 Dimensional Analysis Approach

The dimensional analysis approach is based on the analysis of the relationships between different physical quantities by identifying their fundamental dimensions (i.e.

Length, mass, and time) **[6]** and tracking these dimensionless groups as calculations or comparisons.

Seventeen of parameters which are causing the problem, its units and dimensions are listed in table (1) and are divided into four groups. A definition sketch for parameters is presented in figures (1).

- The first group contains geometrical properties.
- The second group includes the flow properties parameters.
- The third group displays fluid properties.
- The fourth group displays soil properties.

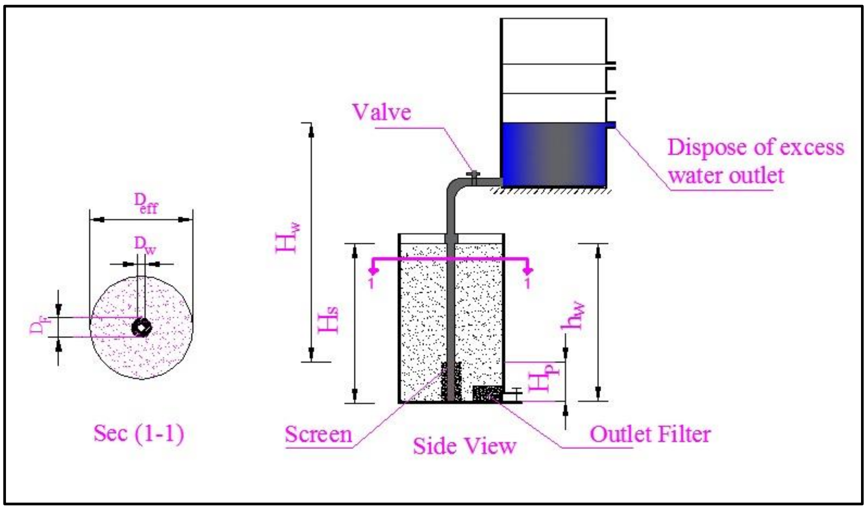

Fig.1: A definition sketch for parameters.

Table 1: Unites and dimension analysis

Symbol	Definition	Units	Dimension
	Geometrical properties		
H_W	Height of water head in general.	m	L
H_S	Height of soil layer which be recharged.	m	L
L_w	Length of well.	m	L
H_p	Height of perforated on the well.	m	L
D_p	Diameter of perforated opening on the side area of well.	m	L
N_p	Number of perforated opening on the side area of well at the height of perforated opening.	m	L
D_{eff}	Diameter of effective area of water recharge.	m	L
D_w	Diameter of recharge well.	m	L
D_F	Diameter of design filter around well.	m	L
	Flow properties		
Q_{in}	Discharge of flow in at any head of water.	m^3/sec	$L^3\ T^{-1}$
$q_{\ out}$	Discharge of flow out at the same head of water.	m^3/sec	$L^3\ T^{-1}$
g	Gravitational acceleration.	m/sec^2	LT^{-2}

Fluid properties			
ρ	Mass density of fluid.	kg_m/m^3	ML^{-3}
Soil properties			
S.G	Soil specific gravity.	-------	Dimensionless
W_{tss}	Weight of T.S.S particles dissolved in water.	gm	M
D_{15}	Particle size of soil for 15% finer.	m	L
D_{85}	Particle size of soil for 85% finer.	m	L

According to Buckingham π-theorem, the general form of the relationship between these variables is as follows:

$$\phi=\left(\frac{D_P}{H_w},\frac{D_{eff}}{H_w},\frac{D_w}{H_w},\frac{D_f}{H_w},\frac{H_s}{H_w},\frac{L_w}{H_w},\frac{H_p}{H_w},N_p,S.G,\frac{D_{15}}{H_w},\frac{D_{85}}{H_w},\frac{H_w^5 g}{Q_{in}^{\ 2}},\frac{W_{tss}}{H_w^3\rho},\frac{q_{out}}{Q_{in}}\right)\ldots\ldots(\text{Eq.1})$$

2.2 Model Similarity

The model simulation is the small case of actual structure, in order to know about the actual performance of prototype, the model must be similar to prototype in all things using known scale this section encompasses the geometrical and kinematic similarity**[7],** as a distorted scale model. The distorted scale model is that model which is made whereas the vertical scale is not the same as the horizontal scale. This section encompasses the geometrical and kinematic similarity, as follows:

2.2.1 Geometrical Similarity

Vertical length ratio is $L_{vm}/L_{vp} = L_{vr}$ (vertical scale ratio) The depth of soil layer which we use to make the recharge process equal to the length of well model was 80 cm equivalent to 16m in prototype. The height of water above the surface of soil in the model was 30cm equivalent to 6m in prototype. The vertical scale is taken = L_{vr} = L_{vm}/L_{vp} = 80/1600 =30/600 =1/20.Also, the horizontal scale ratio= L_{hm} / L_{hp} = L_{hr} (horizontal scale ratio) The diameter of well model was 1.5 inches = 3.81cm, diameter of the soil tank model was 52cm, and the diameter of well prototype was 50 cm, diameter of soil effective area was 6.75m. So, the horizontal scale modeling ratio =3.81/50 = ≈1/13. It is same as effective area scale 52/675= ≈1/13

2.2.2 Kinematics Similarity

In order to undergo a simulation between the model and prototype, all kinematic parameters should be similar. This is described, as follows:

- **Velocity ratio from Froude number similarity is:**

$(Fr)_m= (Fr)_p$

$$\left(\frac{V}{\sqrt{gy}}\right)_m=\left(\frac{V}{\sqrt{gy}}\right)_p$$

$$\frac{V_m}{V_p}=\frac{\sqrt{H_m}}{\sqrt{H_p}}=L_{vr}^{0.50} \rightarrow V_r=\frac{V_m}{V_p}=\sqrt{\frac{1}{20}}=\frac{1}{4.48}\ \ldots\ldots\ldots\ldots\ldots\ldots (\text{Eq.2})$$ **[7]**

- **Discharge ratio**

Q=V.A→

$$Q_r = L_{vr}^{0.50} * L_{vr} * L_{hr} = L_{vr}^{1.50} * L_{hr} = \left(\frac{1}{20}\right)^{1.5} * \left(\frac{1}{13}\right) = \left(\frac{1}{1162.75}\right) \text{….. (Eq.3)}\textbf{[6]}$$

The maximum discharge flow in at the maximum head of water model was 156.5 l/hr, so that the equivalent prototype discharge flow in is 181.97 m3/hr.

- **Time Ratio**

$$\frac{T_m}{T_P} = \sqrt{L_{vr}} \rightarrow T_r = L_{vr}^{.5} \text{ ………………………..….(Eq.4)}\textbf{[6]}$$

3. Experimental Work

The experimental investigation was carried out in the hydraulic laboratory using a three-circular steel tank as shown in definition sketch Fig 7 that has the same dimension with (D) 0.52 m diameter, (H) 0.85 m height. The tank (T1) consist of different water heads 1.20 m , 1.35 m , 1.50 m from above of perforation in (T3). This water has dissolved T.S.S with different concentration, at every head there are faucet to excess water exit from water level at same head. The tank (T2) which is called the feeding tank consists of the same water with the same T.S.S which is feed into tank 1 (T1). This tank has an only benefit that is to keep the water surface in (T1) in constant level through all runs. The tank (T3) is the main tank because it consists of the type of soil which we study it, in addition it consist of a well which receive the water from (T1) and recharge it in (T3) in the soil as explained. There are a constant head pipe connected from (T2) to (T1) through pump 0.5HP and total head 20 m to take the water from (T2) through the constant head pipe to (T1) to keep the surface of water level is stable as shown in Fig 2.

Soil sample which we use sandy soil, make for it sieve analysis to know the granular gradient for soil **[8]**. After that, we use the sieve analysis and start to design the filter of particles surrounding the well and in front of outlet opening which we received the flow rate out from it to prevent any failure causes in soil as shown in Fig 3.

Fig .2: Model in laboratory with different head

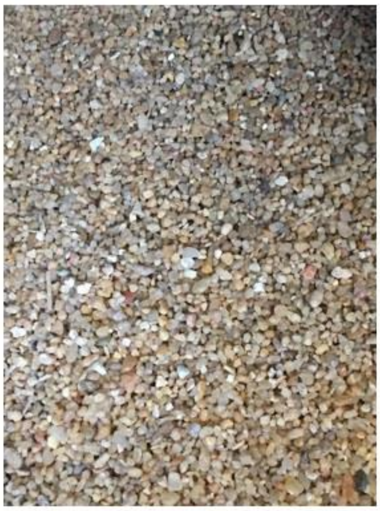

Fig .3: Particles of gravel filter in sand soil by diameter (2mm: 6.3mm)

Design of filter particles calculates from the sieve analysis curve, at the vertical line percentage of all retain at point (d15) take point at horizontal line opening diameter, at the vertical line percentage of all retain at point (d85) take point at horizontal line opening diameter.Measure the distance between the original point to d_{15} horizontal, take point equal to $4d_{15}$ from the original point. Measure the distance between the original point to d_{85} horizontal, take point equal to $4d_{85}$ from the original point, then draw offset for the curve of sieve analysis from this point. This area between two curves is the values of diameter of particle filter **[9]** as shown in Fig 4. Then, we put these particles around the well with a diameter (D_F) and take some of these particles in the steel tube with length 15 cm, 10 cm diameter and put it in front of the faucet of flow out to prevent the soil failure occurs as shown in Fig 5.

Fig .4: Sieve analysis of sandy soil and design of filter

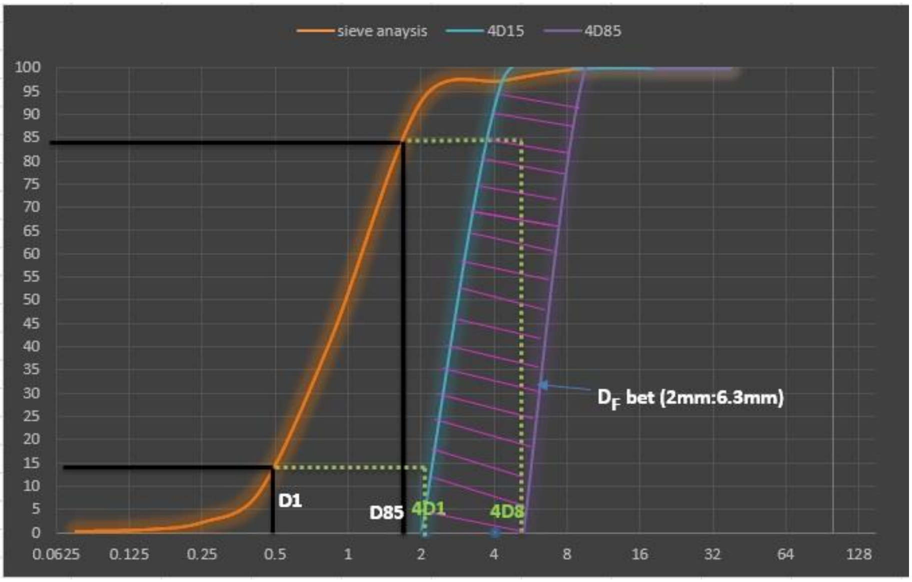

Fig .5: Particles of filter to prevent occurs of soil failure

A nine experiments were conducted in the laboratory. The experiments were recharge in sandy soil, by using three head of water 1.20m, 1.35m, 1.50m. This dimension is measured from surface of water to top of screen at the side area of well at every head we use different concentration of (T.S.S).6000/ppm as first and after finishing the experiment we increase the concentration of (T.S.S) to (1.33T.S.S1) and (1.67 T.S.S1). We measured the decrease of flow rate out from the well at every 15 mine put the results of time in the table and after some minutes the flow rate out be constant and the recharge water comeback through the well to the surface of soil that is guide to stop the process.

3.1 Backwash process

Between two experiments we cannot start another new one experiment unless we must be sure that the soil layer is being cleaned and there is not any suspended solids between filter particles or between the voids particles of soil. When the filters' pores and voids of soil particles become clogged, they need to be cleaned, and one of the best ways to clean the recharge water is backwash it, so backwash process comeback to solve this problem **[10]**.

Backwash process depends on two things, compressed air and strong flow water back. We use air compressor to get compressed air from 1 bar to 2 bar as shown in Fig 6, then we make connection between air compressor and opening of (T3) and be sure that there is not anyway to escape air so as not to affect the backwash process and start compressed from 1 to 2 bar reading on air gauge for 10 min as shown Fig 6. After 10 min for backwash process using compressed air, we use second way to finish this process that is to use pumping water backwards through the filters media the water pressure for 10 min from the outlet of flow out to make good cleaning of filter and voids of particles soil from any (T.S.S).

We notice that the column of water head rises into the well carrying with suspended solids which clogging the voids in the soil and filter, the accumulation of all suspended solids and clay collected on the subsurface of soil. Then, we remove this layer of clay and exchange it by another fresh soil and then start a new experiment.

Fig .6: Air compressor to compressed air to 2 bar in backwash process

3.2 Experimental procedure in sandy soil with different concentration of (T.S.S) with different water head.

The model was prepared to start the experiment in the first case in sandy soil at different head with different suspended solid, the temperature is assumed as constant in normal cases not their effect from it on clogging of the recharge well. Slope of the soil layer is also neglected not their effect of it on recharge water process, the root of the planet measured it by weight and become 0.5% of weight from all total suspended solids as an example, when we add 1080 gm of suspended equal to 8000 ppm the root of the planet was= 0.5% *1080 =5.4 gm as constant through all experiments.

Soil classification of sandy soilsandy soil used in this case as shown in Fig 7, head of water in (T1) at level 1 equal to 1.20m height, the faucet which is found at the same level shall be opened to get rid of excess water, (T2) was filled by water with suspended solids and put the amount of (T.S.S) as equal to 6000 ppm/m³, so that 180 liter equal to 1080gm from total suspended solids dissolved in (T2),(T1) have water at level 1 equal to 30 cm from the bed of tank. Recharge water process has already started and every 15 min we put the glass tube with known volume 1liter and measure the flow rate out from the well and record this result in table, water purity we get it from well has different better than purity from the recharge water. Water we get it was nearly similar to fresh water, where is the fresh water contains 300ppm equal to 300 gm/m³**[11]** that means that the total suspended solids was booked in the voids between particles of soil and particles of filter which be effective on flow rate of well as result of clogging. To start the next experiment, we must wash and clean the soil particles and filter particles from any suspended solids like what we have explained in (3.1 backwash process).

By the time, we change the concentration of (T.S.S) from 6000ppm to 8000ppm and 10000ppm at the same head and every time we record the flow rate out every 15 min in tables and draw the curves of this operation.
Repeating this operation at another head 1.35m and 1.50 m, using also same concentration of (T.S.S) as previous experiments 6000ppm, 8000ppm and 10000ppm and calculate the average of flow rate in every process to make comparison in every case.

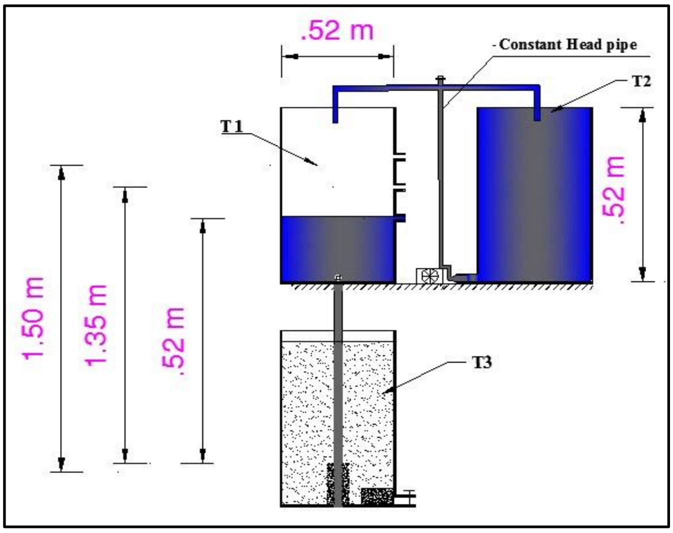

Fig .7: Recharge well model consist of 3 tanks with 1.20 m, 1.35 m, 150 m water head

4. Results Analysis and Discussion

The results analysis with discussions included 2 parts. The first part discusses the results analysis of experimental works, and shows some of comparison of same results in the same experiment by using curves and tables of only (T.S.S) with only head and then draws curves collect 3 curves of different head at same (T.S.S). After we finish this analysis, we will take these results and make similarity between model and prototype at every time and every head to make a good idea about our work and provided the engineers works in the field with this data to help them to overcome the clogging problems, and provided them with the time of clogging well if the well operated in cases of operation cases we study it.

On the other hand, the second part includes the comparison between results at the same time with different concentration of (T.S.S), and explains the value of the flow rate out from recharge well in every case and also compares it with other flow rate in other operation cases to make a good vision of how well this works. In addition, we will compare these results to know the efficiency of every well and effect of (T.S.S) on it. Where the results we get shows that all of (T.S.S) works to decrease the flow rate out of the well and support it also to increase this clogging of well the head of water recharge, but it has not the same effect of (T.S.S), the (T.S.S) have a big effect of clogging almost 75% from all clogging caused of (T.S.S) comparison with increased of the head of water recharge which causes the reduction of flow rate to 25% only from all clogging.

All of these results will show it depend on clogging time of well, but before everything, we must explain the real meaning of clogging. The clogging of well does not mean that the flow rate out of water from the well to finally stop. If the flow rate finally stops, it means that the well failure. But the real meaning of clogging is that it is a decrease of flow rate out through the operation period to reach the constant flow rate out. At this moment, the well can't recharge more than water and flow rate in becoming bigger than flow rate out and then water recharge come back into the well and rising to reach the soil surface then we must stop the experiment and make the backwash process as what we have explained previously.

Results of experiments at 6000ppm with different water head were shown in Table 2 and Fig 8. By studying these results, we can notice that the flow rate in this well was105.6 l/hr, 128.6 l/hr and 156.5l/hr, respectively water head 1.20 m, 1.35 m and 1.50 m and flow rate out from the well at the moment of start experiment was 80.5 l/hr, 96.5l/hr and 118.26l/hr respectively which means that this well losses 24%, 25% and 26% from its efficiency to reach to be able to receive water from the well. This period takes some minutes from flow in and flow water recharge through well, through the filter around well and through sandy soil absorption.

Table 2: Values of flow rate out at 6000ppm with variable water head

Flow Rate Of Flow From Recharge well at head 1.50 m and total suspended solids"6000 ppm" in sand soil											
Time (min)	0	15	30	45	60	75	90	105	120	135	150
Time of flow 1Litre	30.44	33.28	38.48	41.22	43.14	45.78	48.77	52.42	54.8	57.6	57.6
Flow rate L/S	0.033	0.030	0.026	0.024	0.023	0.022	0.021	0.019	0.018	0.017	0.017
Flow Rate Of Flow From Recharge well at head 1.35 m and total suspended solids"6000 ppm" in sand soil											
Time (min)	0	15	30	45	60	75	90	105	120	135	150
Time of flow 1Litre	37.31	41.2	47.77	51.4	53	56.1	58.13	61.13	65.13	66.13	66.13
Flow rate L/S	0.0268	0.0243	0.0209	0.0195	0.0189	0.0178	0.0172	0.0164	0.0154	0.0151	0.015
Flow Rate Of Flow From Recharge well at head 1.20 m and total suspended solids"6000 ppm" in sand soil											
Time (min)	0	15	30	45	60	75	90	105	120	135	150
Time of flow 1Litre	44.74	49.16	53.03	57.52	60.2	61.8	66.17	70.8	71.8	73.20	73.22
Flow rate L/S	0.0224	0.0203	0.0189	0.0174	0.0166	0.0162	0.0151	0.0141	0.0139	0.0137	0.014

This efficiency of flow rate out must be changed ever changes soil type and filter type. Through the following experiment, we measured the flow rate out every 15 min and recorded the value of flow rate out in tables as show in table 2, in which we noticed that the flow rate out decrease every time due to suspended solids.

Total suspended solid is dissolved into water recharge and entred into voids in sandy soil and spacing between particles of filter and fill the voids through time and then flow rate start to be decreased to reach in a constant case.

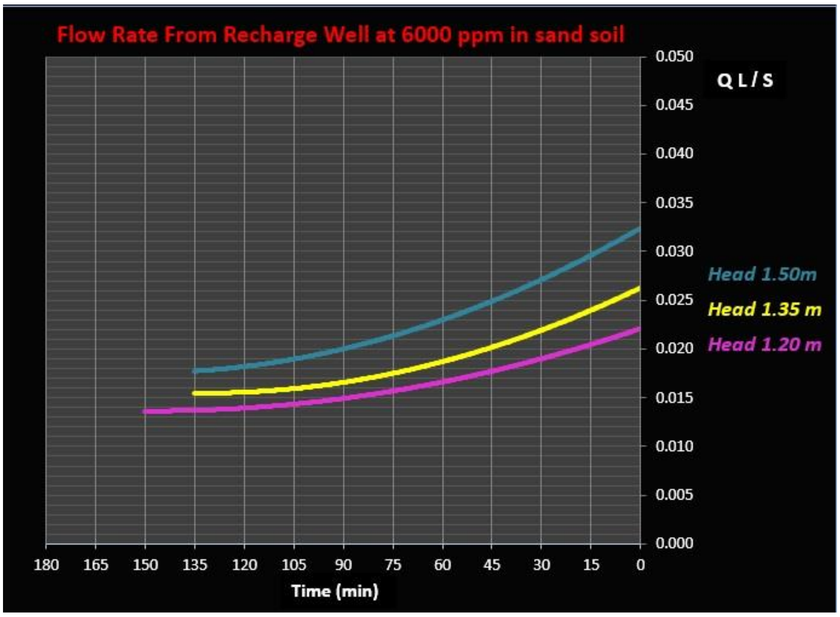

Fig .8:Aggregation curves of flow rate from recharge well at a variable water head with (T.S.S) 6000 ppm in sandy soil

The constant case means the constant flow rate of the well and flow rate in becoming bigger than flow rate out and well can not receive any water recharge and water rising into well and flood to the surface of soil. The average of flow rate out through all time we get it was 57.6 l/hr , 69.12l/hr and 82.8l/hr at 1.20 m , 1.35 m and 1.50 m ,the time of well clogging was 150 min , 135 min and 135 min respectively.

Results of experiments at 8000ppm with different water head were shown in Table 3 and Fig 9. In this case, we increase the concentration of (T.S.S) to (1.33 t.s.s1) and make same thing in this case measuring the average of flow rate and calculating the time of well clogging. The average of flow rate were 57.6 l/hr, 67.3 l/hr and 75.6 l/hr, the time of well clogging were 135 min,120 min,120 min respectively. We can notice that the average flow rate at 1.50 m in 6000 ppm was 82.8 l/hr and was 75.6 l/hr in 8000ppm that means that the increasing of (T.S.S) concentration makes decreasing in flow rate by the time as shown in Fig 9.

Table 3: Values of flow rate out at 8000ppm with variable water head

Flow Rate Of Flow From Recharge well at head 1.50 m and total suspended solids "1.33 T.S.S 1" in sand soil											
Time (min)	0	15	30	45	60	75	90	105	120	135	140
Time of flow 1Litre	30.44	35.42	40.15	47.28	52.16	55.66	61.5	67.36	70.5	70.5	70.5
Flow rate L/S	0.033	0.028	0.025	0.021	0.019	0.018	0.016	0.015	0.014	0.014	0.014

Flow Rate Of Flow From Recharge well at head 1.35 m and total suspended solids "1.33 T.S.S 1" in sand soil											
Time (min)	0	15	30	45	60	75	90	105	120	135	150
Time of flow 1Litre	37.31	43.09	47.14	50.5	54.66	60.1	64.13	67.39	70.39	70.39	70.39
Flow rate L/S	0.0268	0.0232	0.0212	0.0198	0.0183	0.0166	0.0156	0.0148	0.0142	0.0142	0.0142

Flow Rate Of Flow From Recharge well at head 1.20 m and total suspended solids "1.33 T.S.S 1" in sand soil											
Time (min)	0	15	30	45	60	75	90	105	120	135	150
Time of flow 1Litre	44.74	51.11	57.57	59.09	62.13	65.04	67.18	69.33	70.21	71.17	71.17
Flow rate L/S	0.0224	0.0196	0.0174	0.0169	0.0161	0.0154	0.0149	0.0144	0.0142	0.0141	0.0141

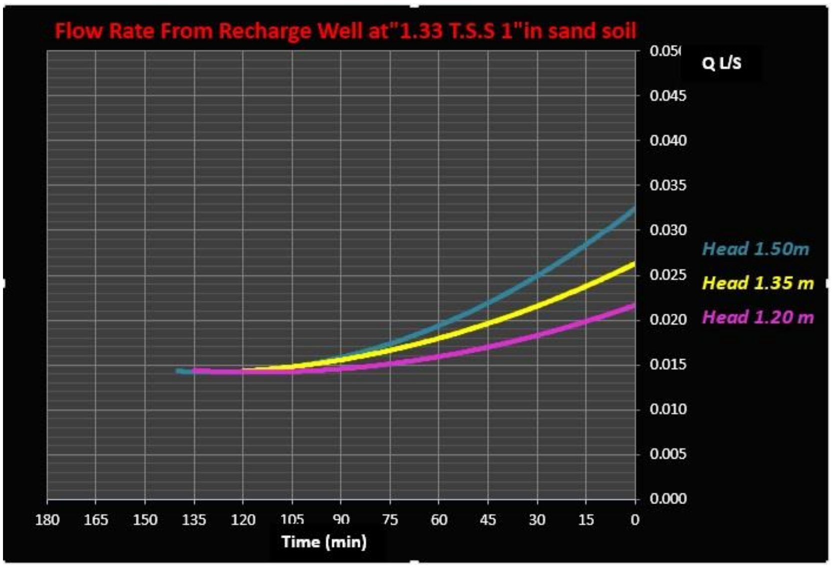

Fig .9:Aggregation curves of flow rate from recharge well at a variable water head with (T.S.S) 8000 ppm in sandy soil

Results of experiments at 10000ppm with different water head were shown in Table 4 and Fig 10, this is the last case of sandy soil type. In this case, we increase the concentration of (T.S.S) to (1.67 t.s.s1) and make same thing in this case measuring the average of flow rate and calculating the time of well clogging. The average of flow rate were 57.6 l/hr, 65.8 l/hr and 69 l/hr, the time of well clogging were 105 min,90 min,90 min respectively. We can notice that when we increase the concentration of (T.S.S) 67% clogging time decease from 135 min to 90 min and average flow rate decrease from 82.8 l/hr at 6000ppm to 69 l/hr at 1000ppm at same head.

Table 4: Values of flow rate out at 10000ppm with variable water head

Flow Rate Of Flow From Recharge well at head 1.50 m and total suspended solids "1.67 T.S.S 1" in sand soil											
Time (min)	0	15	30	45	60	75	90	105	120	135	150
Time of flow 1Litre	30.44	40.16	48.22	57.55	66.33	74.11	84.24	84.24	84.24	84.24	84.24
Flow rate L/S	0.033	0.025	0.021	0.017	0.015	0.013	0.012	0.012	0.012	0.012	0.012

Flow Rate Of Flow From Recharge well at head 1.35 m and total suspended solids "1.67 T.S.S 1" in sand soil											
Time (min)	0	15	30	45	60	75	90	105	120	135	150
Time of flow 1Litre	37.31	45.32	51.44	57.1	63.25	71.77	78.45	78.45	78.45	78.45	78.45
Flow rate L/S	0.0268	0.0221	0.0194	0.0175	0.0158	0.0139	0.0127	0.0127	0.0127	0.0127	0.0127

Flow Rate Of Flow From Recharge well at head 1.20 m and total suspended solids "1.67 T.S.S 1" in sand soil											
Time (min)	0	15	30	45	60	75	90	105	120	135	150
Time of flow 1Litre	44.74	55.42	61.12	65.56	68.73	71.1	73.12	74.55	74.55	74.55	74.55
Flow rate L/S	0.0224	0.0180	0.0164	0.0153	0.0145	0.0141	0.0137	0.0134	0.0134	0.0134	0.0134

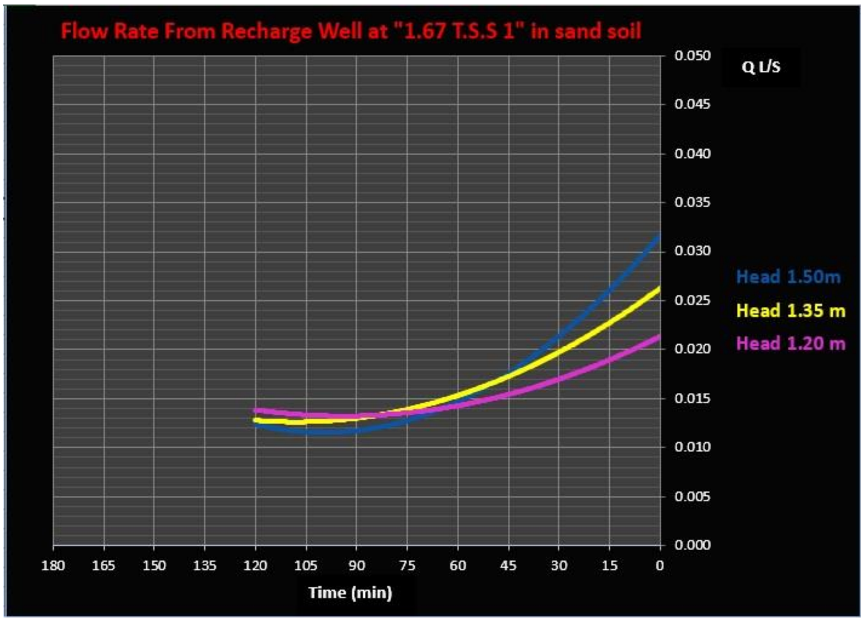

Fig .10:Aggregation curves of flow rate from recharge well at a variable water head with (T.S.S)10000 ppm in sandy soil

4.1 Comparison between results in sandy soil.

At head 1.20 m, 1.35 m and 1.50, we make the experiment in sandy soil with using of different concentration of (T.S.S) 6000 ppm, 1.33 t.s.s1=8000ppm and 1.67 t.s.s 1 =10000 ppm. We can find that at head 1.20 m when we increase the concentration the flow rate out be decreased by the time, we choose to make comparison in three different times at 30 min, 60 min and 90 min. As shown in Table 5 and Table 6, the flow rate was 67.89 l/hr and then became 59.80 l/hr and finally became 54.41 l/hr. All of the previous results at 6000 ppm show that flow rate decrease by the time to reach in a constant case; if we increase the concentration of t.s.s to 1.33%, we notice that the flow rate at every minute we choose is less than the previous case 62.53 l/hr, 57.94 l/hr and 53.59 l /hr respectively.

Table 5:Comparison between average efficiency due to change of (T.S.S) concentration at 1.20 m constant head in sandy soil.

Comparison between 3 result of flow rate (L/hr) in Sand Soil at same head 1.20 m				
Recharge Flow in the well				105.6 L/hr
Flow out from the well at the moment of start experiment				80.5 L/hr
Initial losses in flow rate due to soil saturation and water leekege				24%
Time(min)		30	60	90
T.S.S (ppm)	6000	67.89	59.80	54.41
	8000	62.53	57.94	53.59
	10000	58.9	52.4	49.23
Eficiancy bet 6000→8000 ppm(η%)		8.6	3.2	1.5
Average eficiancy(η%)		-4.4		
Eficiancy bet 6000→10000 ppm(η%)		15.3	14.2	10.5
Average eficiancy(η%)		-13.3		

It is worthy of mention that, if we change the concentration 1.33% at the same head, the flow rate efficiency decrease 4.4% as shown in table 5-20, with same way if we change the concentration of (T.S.S)to 1.67%, the flow rate efficiency decrease 13.3%. The decrease of flow rate efficiency means that decrease or constant of flow rate out and decrease of clogging well time.

Table 6:Comparison between average flow rate due to change of (T.S.S) concentration at 1.20 m constant head in sandy soil

Clogging Results	6000 ppm	At 150min
	Recharge flow in	105.6 L/hr
	Average recharge flow out through operation time	57.6 L/hr
	8000	At 135 min
	Recharge flow in	105.6 L/hr
	Average recharge flow out through operation time	57.6 L/hr
	10000	At 105 min
	Recharge flow in	105.6 L/hr
	AAverage recharge flow out through operation time	57.6 L/hr

On the other hand, if we change the water head from 1.20 m to 1.35 m with 12.5% increase ratio, we will find that the flow rate efficiency changes from the 4.4 % decrease to 5.4%, that gives us an important factor that due water head affects of efficiency of flow rate out with range of 20 %.

If water head changes from 1.35 m to 1.5 m, the efficiency changes from 5.4 % to 17.1 % with 31 % increase ratio that means that water head can affect the flow rate out if we have constant head is between 20 % to 31% respectively. Clogging well time is the second parameter effect with change of concentration of (T.S.S) and change of water head the clogging time is 150 min, 135 min and 105 min respectively at 6000ppm, 8000 ppm and 10000 ppm.

Back to theoretical approach by using rules of similarity with horizontal scale 1:13 and vertical scale 1:20, we can calculate the time of clogging well, if we have water head above of perforated opening 120 cm in model type equal to 24 m in prototype and well diameter was 50 cm and water recharge contain dissolve (T.S.S) 6000ppm the well will clogged after 150 min in model equal to 11.18 hr in prototype, if the (T.S.S) increases to (1.33 t.s.s1), the well will be clogged after 135 min equal to 10 hr. If the (T.S.S) increases to (1. 67 t.s.s1), the well will be clogged after 105 min equal to 7.8 hr in which this result is shown in table 7. In addition, table 8 shows the real time of well clogging in prototype at different head 1.35 m, 1.50 m and explains the average flow rate should be gotten in prototype, where flow rate average decreases whenever (T.S.S) concentration increases from 96 m³/hr to 88 m³/hr and become 80 m³/hr.

Physical clogging well due to suspended solids depends on two important parameters; water head which controls the flow rate and exchange of (T.S.S) concentration. The first parameter affects the clogging well by 20 – 30 % from all clogging occur in sandy soil. Table 8 shows the similarity of prototype with all real geometrical properties and flow properties and clogging time in sandy soil.

Table 7:Similarity of clogging time between model and prototype at water head 1.20 m and variables (T.S.S) concentration in sandy soil

Similarity between Model and Prototype at head 1.20m and 6000 ppm in Sand Soil

	Model		Prototype	
Flow in	105.6	L/hr	123	M3/hr
Average Flow out through operation time	57.6	L/hr	67	M3/hr
Clogging Time	150	Min	671 Min = 11.18	hr

Similarity between Model and Prototype at head 1.20m and 8000 ppm in Sand Soil

	Model		Prototype	
Flow in	105.6	L/hr	123	M3/hr
Average Flow out through operation time	57.6	L/hr	67	M3/hr
Clogging Time	135	Min	604 Min = 10.06	hr

Similarity between Model and Prototype at head 1.20m and 10000 ppm in Sand Soil

	Model		Prototype	
Flow in	105.6	L/hr	123	M3/hr
Average Flow out through operation time	57.6	L/hr	67	M3/hr
Clogging Time	105	Min	470 Min = 7.83	hr

To optimize the decrease of flow rate efficiency due to increase (T.S.S) concentration, at flow rate 105.6 l/hr use fig 10, for flow rate 128.6 l/hr use fig 11 and for 156.5 l/hr use fig12.

Table 8:Geometrical properties and flow properties for prototype in sandy soil

Geometrical properties and flow properties in prototyp in sandy soil					
Water Head	(T.S.S) Concentration	Well Diameter	Perforated Opening Ratio% (l / L)	SAND SOIL	
				Average flow rate out M^3/hr	Clogging Time (hr)
24 m	6000 ppm	50 cm	25%	67	11.18
	1.33% t.s.s1			67	10.06
	1.67% t.s.s1			67	7.83
27m	6000 ppm	50 cm	25%	80	10.06
	1.33% t.s.s1			78	8.80
	1.67% t.s.s1			77	6.71
30m	6000 ppm	50 cm	25%	96	10.06
	1.33% t.s.s1			88	8.94
	1.67% t.s.s1			80	6.71

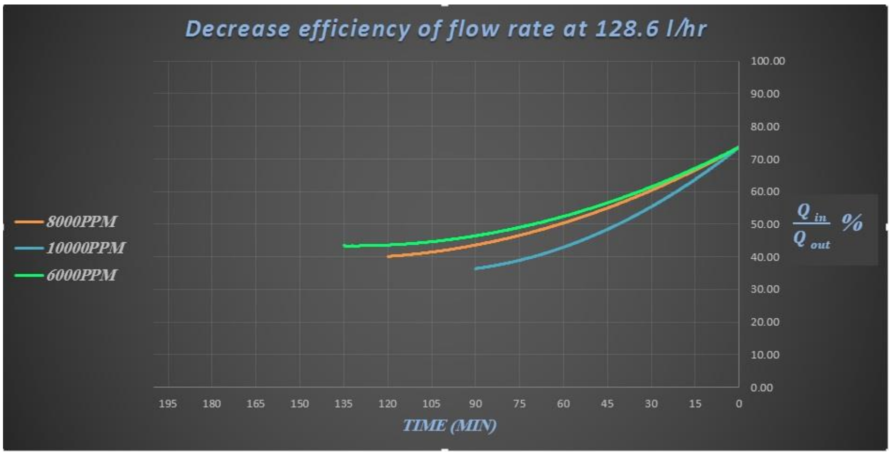

Fig .10: Decrease efficiency of flow rate due to increase (T.S.S) concentration by the time at 105.6 l/hr in sandy soil

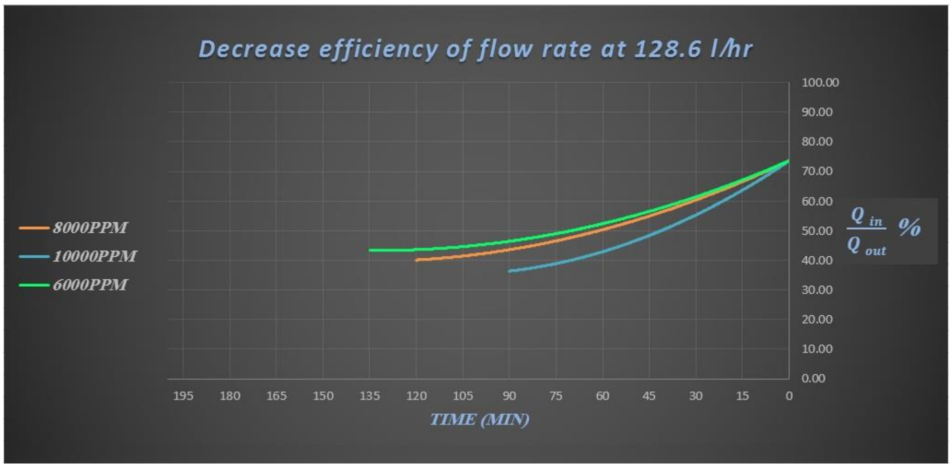

Fig .11: Decrease efficiency of flow rate due to increase (T.S.S) concentration by the time at 128.6 l/hr in sandy soil

Fig .12: Decrease efficiency of flow rate due to increase (T.S.S) concentration by the time at 156.5 l/hr in sandy soil

5. Conclusions

Based on the above investigation phases, the deduced conclusions are as follows:

- In sandy soil at same head when we increase the total suspended solids decrease, the efficiency from 4.4% to13 .3% if the (T.S.S) increases from 6000ppm to 10000ppm by increasing ratio of 67%.
- The recharge in the soil has a large spacing voids works to increase the recharge time and makes an improvement of flow rate out from well.
- A good design of filter around well and in front of outlet water has an important effect of water purity and keep soil in stable case not failure causing and improvements of well performance.
- Physical well clogging due to suspended solids depends on two important factors; flow rate from water head and (T.S.S) concentration. Effect of (T.S.S) concentration is higher than the water head reach to 70%: 80% and effect of water head was 20%: 30%.

- Backwash processing is the most important factor of this operation which improves the performance of wells due to operation and clears all suspended solids existed into soil voids.

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