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EFFECT OF ROOF TANKS FILLING ON THE HYDRAULIC PERFORMANCE OF WATER SUPPLY PIPES NETWORK

Hassan I. Mohamed [1], Mohamed S. El-dardir [2] and Ebtehal A. Abdel-Hafez [3]

[1, 2] *Civil Eng. Department, Assiut University*
[3] *Water and wastewater company of Assiut*

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ABSTRACT

Assiut city suffers from lack of available lands to build houses. The price of an apartment in Assuit city is considered the highest price in Egypt. So, people are forced to replace the old houses with 11 floors ones. This situation makes the city infrastructure under pressure and challenges. One of these challenges is the drinking water supply network, which is designed to lift water only to the third floor. In this situation, to feed the floors above the third floor with water, roof tanks are built above towers and are supplied with water from the main network through private pumps. These pumps fill the tanks through a short period and operate for limited times at a day. The water supply network is not designed for such type of operation. In this research, the effect of existing roof tanks on the flow behavior in the water supply pipes network is studied. Different Scenarios are considered for roof tanks filling through changing the period and time of filling. The actual pipes network is planned to serve new area and all the building in this area have 11 floors towers. For each scenario, pressure head, velocity and water age at different nodes and pipes in the network are predicted through extended period simulation.

Keywords: Extended period simulation, pipe network, roof tanks, water age, flow control, water supply.

1. Introduction

Water network simulation provides efficient and fast method for predicting the hydraulic behavior of the network: calculating pipe flows, velocities, head-losses, pressure heads, tank levels, tank inflows and outflows and water quality. Mohamed and Abozeid [11] studied the effect of abnormal operation conditions of water distribution network on pressure head and chlorine concentration through the network. They concluded that there are many parameters have significant effect on the network, among of which is pipes roughness, leakage through the pipes and closing some pipes. Lima et al. [9] presented a method for the optimal design of water distribution network considering energy recovery. They considered the use of pumps as turbines for energy production. Choi et.al. [4] observed a real-time flow data in combination with pressure and turbidity in NS City of Korea. The experimental results showed that the intensive water use of large-demand customer influences on pressure drop by the magnitude of 0.5 kg/cm^2 and on instantaneous values of turbidity reaching 15 times of average turbidity. Pietracha-Urbanik and Studzinsk [13] studied the consequences of pipe failures on the water supply pipes network. They determined the effect of failure in individual sections in relation to the area with pressure lowered below the required value, the duration of that pressure reduction, and the potential number of recipients affected by limitation of water supply. Ali et.al. [1] has calibrated and validated the Bently WaterGEMS V8i software.

If the WDN (water distribution network) doesn't operate in normal conditions, unequal distribution of water will occur. So, customers may tend to construct their own local storages (e.g. roof tank). Therefore, the tanks filling process modify the profile of the diurnal curve of demands. So, in WDN with private tanks, specific models are needed to be developed correctly to simulate the network operation, De. Marchis et al. [5, 6]. Mohamed and Gad [12] studied the influence of the storage cisterns size and the turnover depth on residual chlorine decay and water age in the tanks. Results showed that oversized storage cisterns could have negative impacts on water quality, including increased water age, reduced disinfectant residuals, and increased growth of disinfectant by-products. However, these tanks play an important role in securing of water supply during interruption as the water supply cannot be driven up to high floors with the available pressure in the city water distribution network. Berardi et al. [3] showed that the prediction of WDN water supply capacity achieved by a model accounting for the filling/emptying of local tanks is different from both classical demand-driven analysis and the pressure-driven analysis based on Wagner's demand-pressure relationship at each node. Giustolisi et al. [8] developed a formulation for nodal water withdrawals in WDN models accounting for the filling/emptying process of inline tanks between the hydraulic network and customers. They introduced the formulation in a widely used method for steady-state WDN modeling, the global gradient algorithm, and its effectiveness to increase the hydraulic accuracy of results is discussed using a simple case study. Smith et al. [14] referred that building can achieve a 45% reduction in pumping energy by replacing traditional break tank systems with pressurized booster systems.

To many utilities, water age is an important performance indicator, as the availability of safe and pathogen-free drinking water is vital to public health. Wang et al. [16] observed that water age is a strong factor in shaping bacterial and eukaryotic community structure. Recently, hydraulic models are developed to analyze the age of water that is considered to be a preliminary step. Soumya et al. [15] preformed a water age analysis for a case study (Tilehurst – Newbury area of Berkshire of UK), where a transfer main supplied an uphill region and traversed through environmental constraint zones. Transfer main of 18.38 km length is designed for a mix of gravity flow and uplift pumping. Water age simulated for 7-day (168 hrs) period indicated that it would take 17.5 hrs for water to travel 18.38 km main pipeline and this time to travel reduced with an increase in pipe diameter. Further, the location of pumping station had direct impact on 'travel time'. Age old water (as old as simulation period) was observed at dead ends.

2. Theoretical approach

An event or condition at any point in the water system can affect all other parts of the system and this complicates the approach that the engineer must take to find a solution. So, there are some governing principles that drive the behavior of the network including principles of conservation of mass and energy.

At any node in a water system, the total mass in-flows must equal the out-flows plus the change in storage, in case of using storage tanks(Eq. (1))[2,10]:

$$\sum Q_{in} * \Delta t = \sum Q_{out} * \Delta t + \Delta V_s = \mathrm{H} \quad (1)$$

Q_{in}:Total flow into node (m^3/s), Q_{out}: Total demand at node (m^3/s), Δt: Change in time (s) and ΔV_s: Change in storage volume (m^3).

The total energy at any section in the pipe consists of three types of energy. There may also be head added to the system by pump or head removed from the system due to friction and any sudden change in the water flow system (Eq. (2)) ([2,10]):

$$Z_1 + \frac{P_1}{\mathrm{p}*g} + \frac{v^2{}_1}{2g} + h_p = Z_2 + \frac{P_2}{\mathrm{p}*g} + \frac{v^2{}_2}{2g} + h_l \quad (2)$$

H: Total energy per unit weight or total head (m), Z: Elevation head (m), $\frac{P}{\mathrm{p}*g}$: Pressure energy per unit weight or pressure head (m), $\frac{v^2}{2g}$: Kinetic energy per unit weight or velocity head (m), h_p = Head gained from a pump (m) and h_l= Head loss (m).

Flow control means that a specific number of tanks is filled in specific time to make the follow constant as it possible. So that a simple equation (Eq.(3)) have been developed to get the number of tanks that can be filled at any hour during the day:

$$\left(Q_{avg} * F + N_{(0-12)} * Q_p\right) / \left(Q_A + N_6 * Q_p\right) = 1 \quad (3)$$

Q_{avg}: is the average demand that is needed for the floors from the first till the third for all towers, F: is the pattern multiplication factor of the Egyptian code demand curve each two hour, $N_{(0-12)}$: is the number of roof tanks that can be filled at any two hours during the day, Q_p: is flow pumped to fill these number of roof tanks , N_6: is the number of roof tanks that can be filled from 11 am till 1 pm that represents the peak time and Q_A: is the maximum demand that is needed for the floors from the first till the third for all towers.

3. Materials and methods

3.1. Description of the used water distribution network

The network serves a new planned area beside AL-Azhar minibus station. It is surrounded by the Rail Way line, AL-Azhar University and EL-Ebrahimia Canal. The district area is about 206308.95 m^2 (49.12 feedan). It is expected to accommodate 57,816 capita. The area is planned as 61.68 % residential area, 2.95% as service area and 35.37% as roads and open areas. The district contains 88 multi-store houses. All the buildings consist of eleven floors. Twenty five towers contain eight apartments on each floor, forty towers contain ten apartments in each floor and twenty three towers contain twelve apartments on each floor. Water supply pipes network is designed according to the Egyptian code. The water is supplied in the network by booster pump at point Pm-1 from Asyut City pipes network, as shown in Figure (1). The average pressure in the feeding pipe is 0.5 bar. Table (1), shows the booster pump characteristics. The network layout is planned as a gridiron system. Table (2), shows the lengths and diameters of different pipes. Upvc pipes are used in the network. The total length of the pipes network is about 5 km.

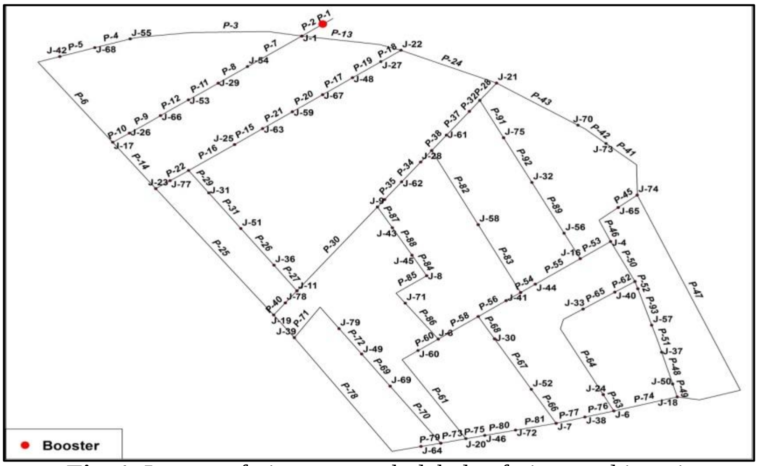

Fig. 1. Layout of pipes network, labels of pipes and junctions.

Table 1.
Booster pump characteristics.

Flow (l/s)	Head (m)
0	28
335	21
670	0.5

Table 2.
Lengths and diameters of the pipes in water supply network.

Pipe	Length(m)	Nominal Diameter (mm)	Pipe	Length(m)	Nominal Diameter (mm)	Pipe	Length(m)	Nominal Diameter (mm)
P-1	13	560	P-16	58	110	P-31	55	250
P-2	27	560	P-17	38	200	P-32	17	315
P-3	182	160	P-18	25	225	P-33	18	250
P-4	39	110	P-19	36	225	P-34	32	250
P-5	39	110	P-20	38	160	P-35	28	225
P-6	150	110	P-21	38	160	P-36	12	225
P-7	68	400	P-22	23	250	P-37	38	315
P-8	37	400	P-23	18	250	P-38	24	315
P-9	39	355	P-24	108	450	P-39	19	110
P-10	21	355	P-25	199	250	P-40	20	110
P-11	38	400	P-26	57	225	P-41	79	250
P-12	35	355	P-27	40	160	P-42	37	315
P-13	107	450	P-28	28	400	P-43	100	315
P-14	73	355	P-29	35	250	P-44	35	250
P-15	36	110	P-30	134	110	P-45	25	250
P-46	54	225	P-62	25	160	P-78	205	200
P-47	332	110	P-63	23	110	P-79	21	160
P-48	41	110	P-64	129	110	P-80	33	125
P-49	17	110	P-65	40	160	P-81	44	125
P-50	55	225	P-66	49	110	P-82	104	200

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Table 2. (Cont)

Pipe	Length(m)	Nominal Diameter (mm)	Pipe	Length(m)	Nominal Diameter (mm)	Pipe	Length(m)	Nominal Diameter (mm)
P-51	35	160	P-67	73	125	P-83	95	160
P-52	9	200	P-68	32	160	P-84	30	160
P-53	38	125	P-69	50	160	P-85	54	160
P-54	18	160	P-70	88	110	P-86	56	110
P-55	57	200	P-71	79	200	P-87	30	200
P-56	35	200	P-72	39	160	P-88	40	200
P-57	18	200	P-73	27	160	P-89	71	225
P-58	37	110	P-74	69	110	P-90	36	225
P-59	13	110	P-75	20	160	P-91	52	250
P-60	25	110	P-76	31	110	P-92	63	250
P-61	139	110	P-77	31	110	P-93	47	200

3.2. Diurnal curve of demands

Diurnal curve of demands allows applying automatic time-variable changes in demands throughout the day, reflecting times when people are using more or less water than average. Figure (2), represents the relation between the multiplication factors that equal the needed demand at any time divided by the average demand, and the time. As shown in Fig. (2), there is a peak in the diurnal curve at afternoon as people take showers and prepare lunch, and another peak in the evening as people prepare dinner. Throughout the night, the pattern reflects the relative inactivity of the system, with very low flows compared to the average.

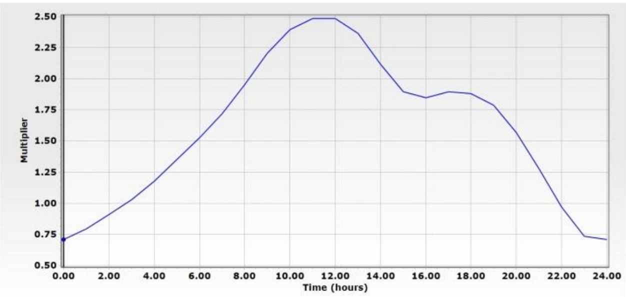


Fig. 2. Diurnal curve of demands, according to the Egyptian code [7].

3.3. Methodology

Different Scenarios are considered for roof tanks filling through changing the period and time of filling. Scenario S_1, is a bench mark scenario, it is considered that all floors are fed directly from street pipes network without any roof tanks. In Scenario S_2, it is considered that the first three floors of the building are fed directly from street pipes network, while the other tower eight floors are fed from tower roof tanks and that all roof tanks are filled once at mid-day. In Scenario S_3, it is considered that the first three floors are fed directly from street pipes network, while the other eight floors are fed from roof tanks and that all roof tanks are filled once at midnight. In Scenario S_4, it is considered that the first three floors are fed directly from street pipes network, while the other eight floors are fed from roof tanks and roof tanks are divided into three groups each group is filled once at midday. In Scenario S_5, it is considered that the first three floors are fed directly from street pipes network, while the other eight floors are fed from roof tanks and roof tanks are divided into three groups each group is filled once at midnight. In Scenario $\underline{S_6}$, it is considered that the first three floors are fed directly from street pipes network, while the other eight floors are fed from roof tanks and all roof tanks are filled twice a day. In Scenario $\underline{S_7}$, it is considered that the first three floors are fed directly from street pipes network, while the other eight floors are fed from roof tanks and all roof tanks are filled three times a day. In Scenario $\underline{S_8}$, it is considered that all floors are fed from roof tanks and roof tanks are divided into eight groups that is filled randomly. In Scenario $\underline{S_9}$, it is considered that the first three floors are fed directly from street pipes network, while the other eight floors are fed from roof tanks and that the roof tanks are divided to twelve groups such that the total flow at any hour is approximately the same. In Scenario $\underline{S_{10}}$, it is considered that all floors are fed from tower roof tanks and that the planned area is divided into eight suburbs, each suburb is supplied with water in specific time. The water is delivered to one suburb and interrupted in the other suburbs.

A comparison of these scenarios is adopted to explain the effect of the following parameters on the hydraulic performance of the water supply pipes network.

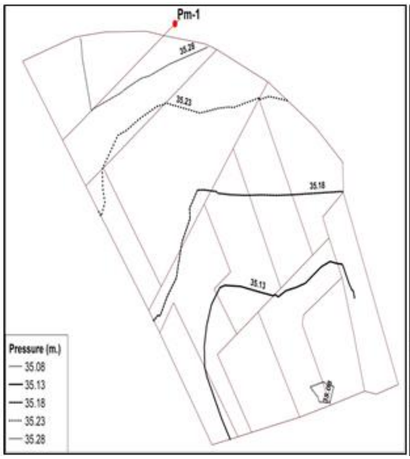
1.Time and period of filling.
2.Number of roof tanks filled at the same time.
3.Number of times of filling.
4.Flow control.

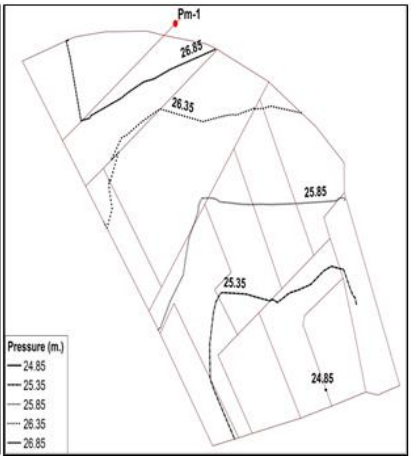
4. Results and discussions

The results of solving the pipe networks using Bently WaterGEMS V8i software for the simulation of flow and water age in the pipes network are discussed. The results are for different scenarios of the roof tanks filling.

4.1. Effect of time of filling on the flow and water quality

Figures (3-a) and (3-b), show contours of pressure head at 0:00 and 12:00 hour respectively, for scenario S_1 at which is assumed that all floor withdraw directly from the street pipes network. It can be shown from these figures that, pressure variation during the day depends on the required demand.

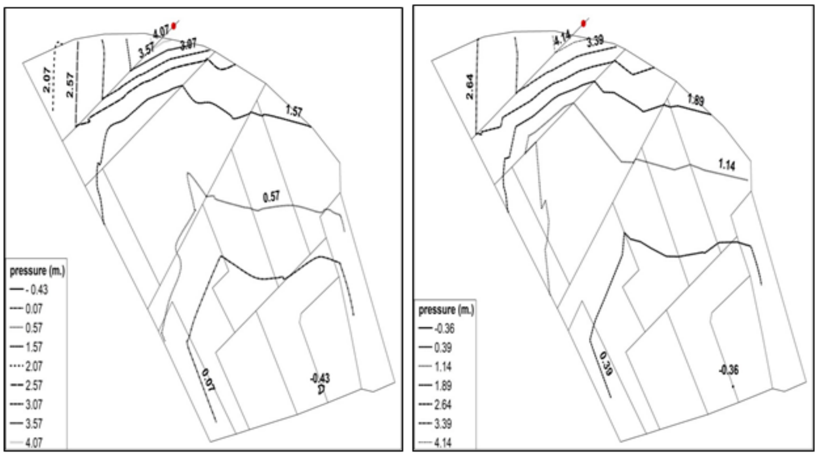




(a) **(b)**

Fig. (3-a). Contours of pressure head at 0:00 hour, for S_1.
Fig. (3-b). Contours of pressure head at 12:00 hour, for S_1.

Figures (4-a) and (4-b), show pressure head contours for scenarios S_2 and S_3, respectively, at the hours of roof tanks filling. As shown in Fig.(4-a), there is a severe variation in pressure head distribution. Where all roof tanks are filled in the same time from 11 :00 till 13:00 in the peak hour which means that there is a high demand required in a short time in addition to the peak demand at the first three floors. Some areas in the network have negative pressure which means that there is a water interruption in these areas even for the first three floors and there is injustice in water distribution as the areas far from the water station have no water. Also, as shown from Fig.(4-b), when filling the roof tanks at 0:00 at midnight, i.e. at low demand hour, there is no improvement in pressure head in the network.



(a) **(b)**

Fig. (4-a). Contours of pressure head at 12:00 hour, for S2.
Fig. (4-b). Contours of pressure head at 0:00 hour, for S3.

Figure (5), shows the variation of pressure head with time at J-24 for the two scenarios of roof tanks filling at midday S_2 and midnight S_3. It is noticeable from this Figure that, the pressure drops suddenly during hours of filling without regards to the time of filling and after filling of tanks returns to its original value.

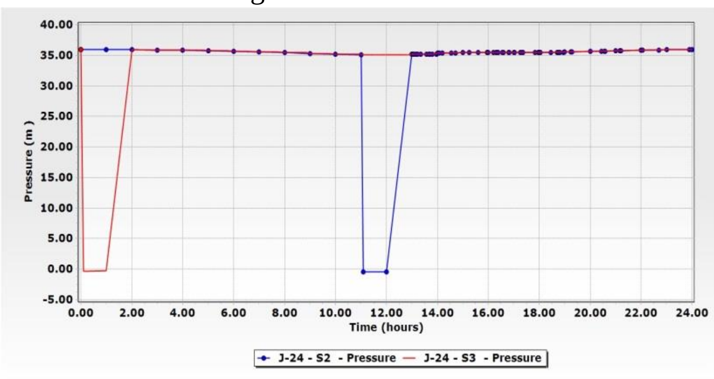


Fig. 5. Variation of pressure with time at J-24 for S_2 and S_3.

Figure. (6), shows the time variation of flow velocities in pipe P-2 for scenarios S_2 and S_3 of roof tanks filling. As shown from this figure, at the period of filling the velocity jumps to a value higher than 2 m/s without regards to the time of filling at night or day then drops to a value less than 0.5 m/s.

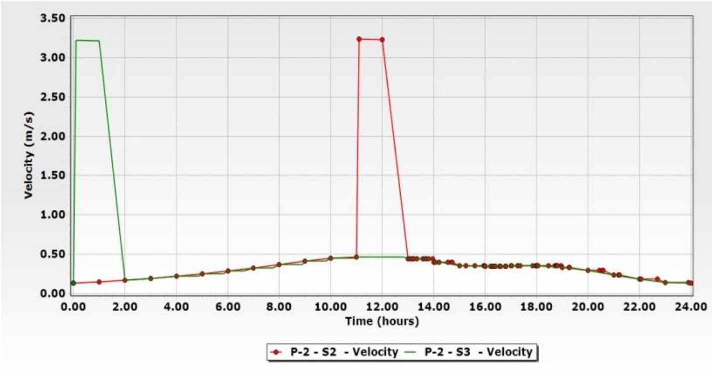


Fig. 6. Variation of flow velocities with time in pipe P-2 at S_2 and S_3.

Figure. (7) shows the variation of water age values with time at J-38 for the two cases of roof tanks filling at midday and midnight. It is noticeable from this figure that in scenario S_2 water is kept in pipes for a longer period as almost all the needed consumption is concentrated at midday, and small demand is needed during the rest of the day. While in scenario S_3 the peak demand and the filling process occur at different times, so the water does not stay long period in the pipes network.

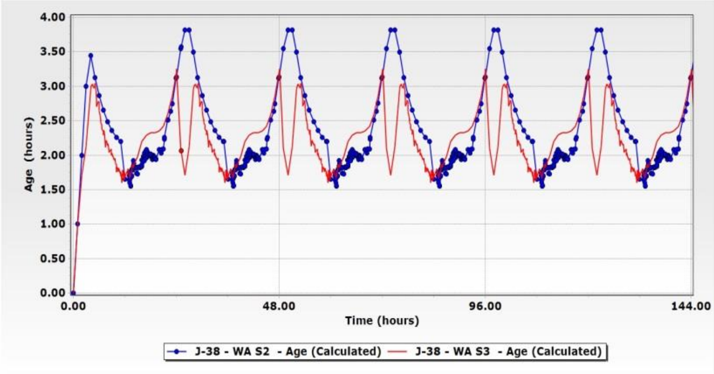


Fig. 7. Variation of water age with time at junction J-38 for S_2 and S_3.

4.2. Effect of time of mutually filling of roof tanks on the flow and water quality

Figures (8) and (9), show the pressure head distribution at node J-35 for scenarios S_2& S_4 and S_3&S_5, respectively. It is clear from these figures that the drop in pressure head for scenario S_4 is less than that for scenario S_2 and the drop in pressure head for scenario S_5 is less than that for scenario S_3. However, it will continue to l ong period due to the filling of tanks in a mutually three periods.

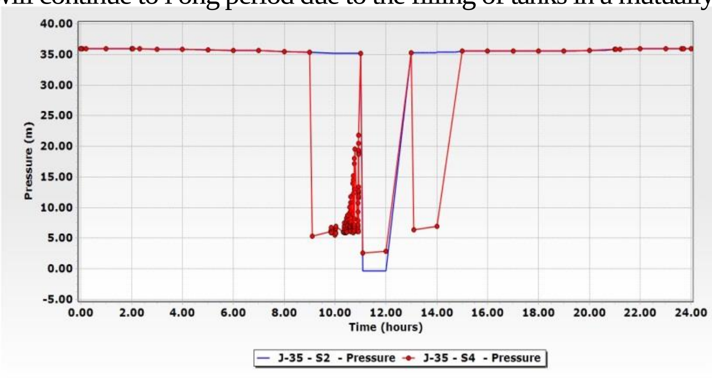


Fig. 8. Variation of pressure with time at J-35 for S_2 and S_4.

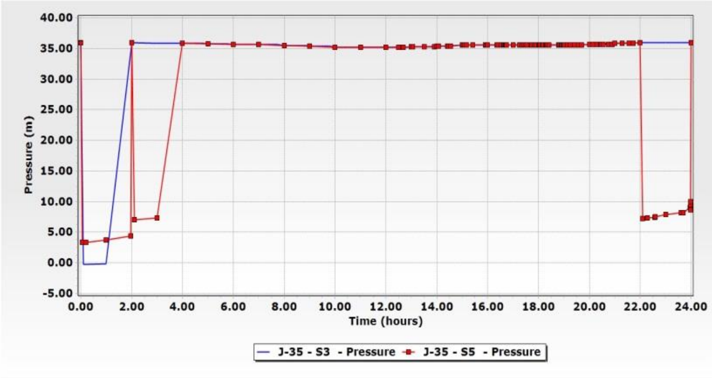


Fig. 9. Variation of pressure with time at J-35 for S_3 and S_5.

Figures (10) and (11), show the time variation of flow velocities in pipe P-2 for scenarios S_2 & S_4 and scenarios S_3 & S_5. It is clear from these figures that velocity values for scenario $S_4$are less than that for S_2 and velocity values for scenario S_5 is less than that for scenario S_3. However, its value still higher than 2.0 m/s and continued for a long period compared to filling all the roof tanks at the same time.

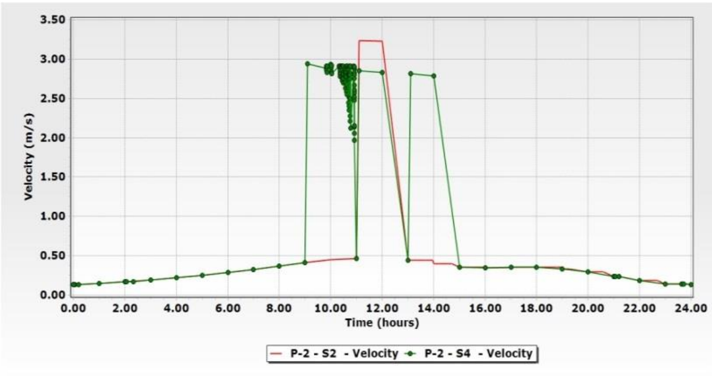


Fig. 10. Variation of flow velocities with time in pipe P-2 at S_2 and S_4.

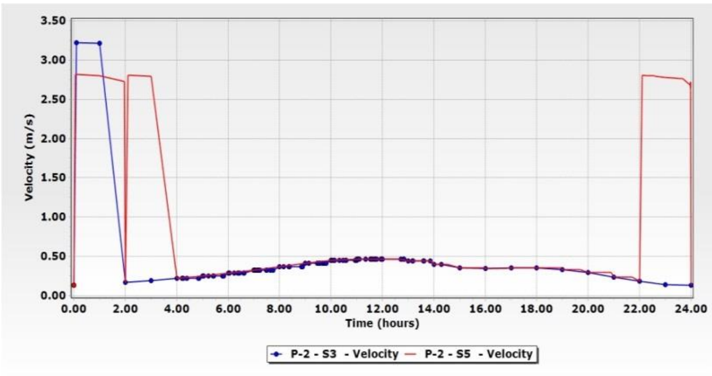


Fig. 11. Variation of flow velocities with time in pipe P-2 at scenarios S_3 and S_5.

Figures (12) and (13), show the variation of water age with time at node J-38 for scenarios S_2 & S_4 and S_3 & S_5. It is clear from these figures that the depression in water age for S_2 is less than that for S_4 and that the increase in water age for S_5 is less than that for S_3.

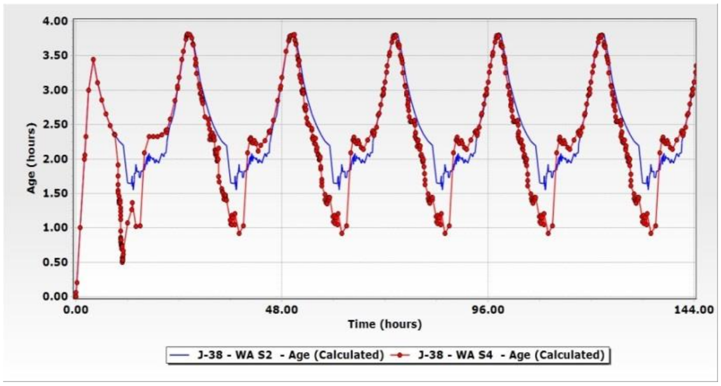


Fig. 12. Variation of water age with time at J-38 for scenarios S_2 and S_4.

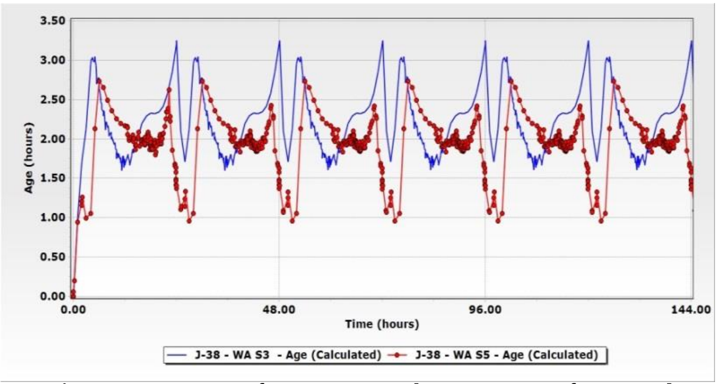


Fig. 13. Variation of water age with time at J-38 for S_3 and S_5.

4.3. Effect of time of filling distribution on the flow and water quality

Figure (14), shows the pressure head variation with time at node J-38 for scenarios S_3,S_6 and S_7. It is observed in this Figure. that, dividing the time of filling to two intervals (S_6) and three intervals (S_7) have no significant effect on the pressure head at filling periods.

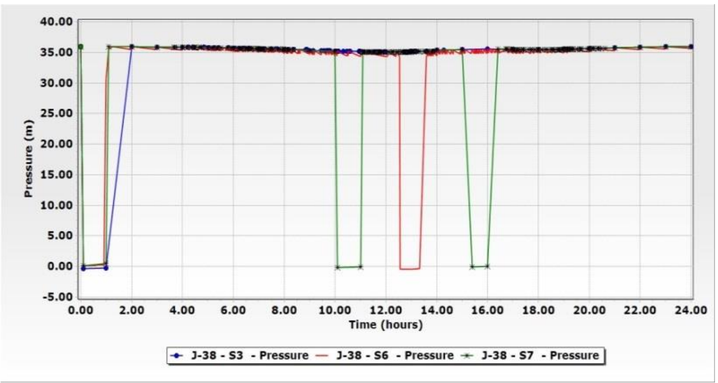


Fig. 14. Variation of pressure with time at J-38 for S_3, S_6 and S_7.

Figure(15), shows the time variation of flow velocities in pipe P-2 for scenarios S_3, S_6 and S_7. It is observed from this Fig. that, distributing the time of filling to more than one interval doesn't affect the flow velocity values at filling periods.

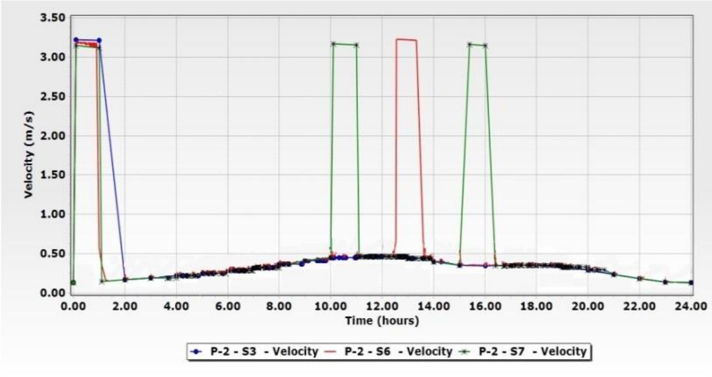


Fig. 15. Variation of flow velocities with time in pipe P-2 at scenarios S_2, S_6 and S_7.

Figure (16), shows the water age variation with time at node J-3 for scenarios S_3,S_6 and S_7. It is observed from this Figure. that, distributing the time of filling to more than one interval increases the fluctuation in the water age.

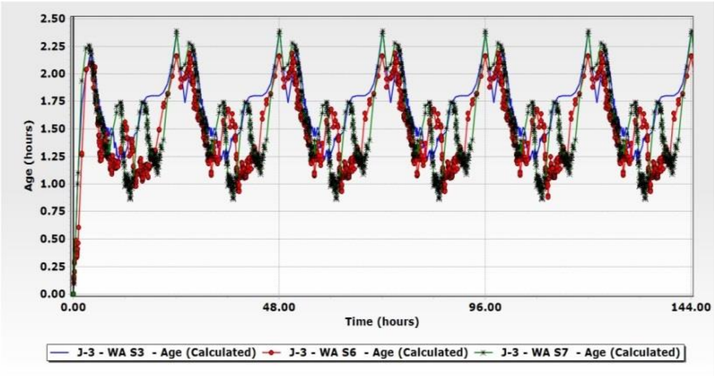


Fig. 16. Variation of water age with time at J-3 for scenarios S_3, S_6 and S_7.

4.4. Effect of randomly filling of roof tank on the flow and water quality

Figure (17), shows the pressure variation with time at J-52 for scenarios S_1, S_2 and S_8. It is shown from this Figure. that, pressure head increases during filling process due to the distribution of filling time through all the day and became very similar to the values of withdrawn from the pipes network directly.

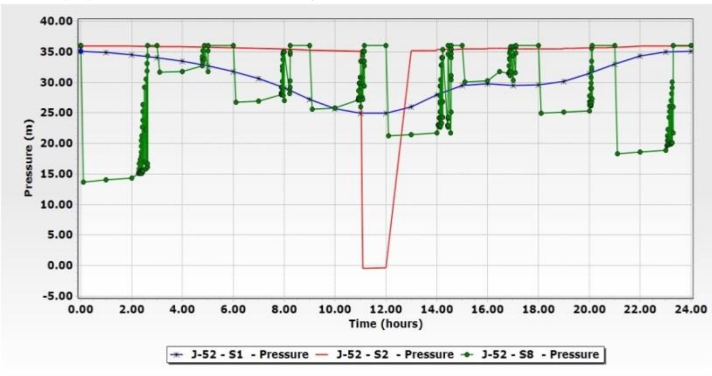


Fig. 17. Variation of pressure with time at J-52 for scenarios S_1, S_2 and S_8.

Figure (18), shows the time variation of flow velocities in pipe P-2 for scenarios S_1, S_2 and S_8. It can be shown from this Figure. that, velocity values for case of filling the roof tanks through all the day is very similar to these values of withdrawn directly from the street pipes network.

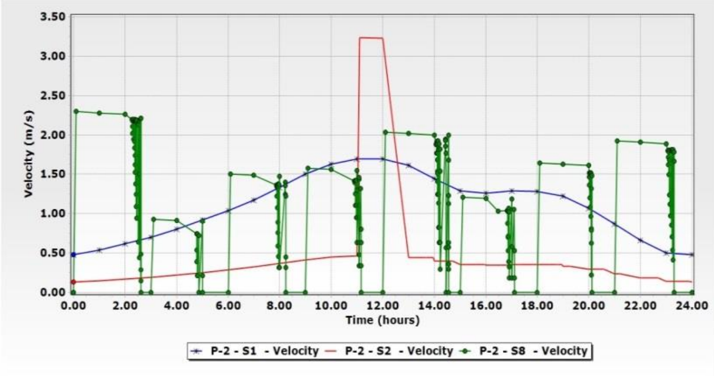


Fig. 18. Variation of flow velocities with time in pipe P-2 at scenarios S_1, S_2 and S_8.

Figure (19), shows the water age variation with time at J-6 for scenarios S_1, S_2 and S_8. It can be shown from this figure that, water age for case of distributing the filling through all the day is less than that of filling at one time.

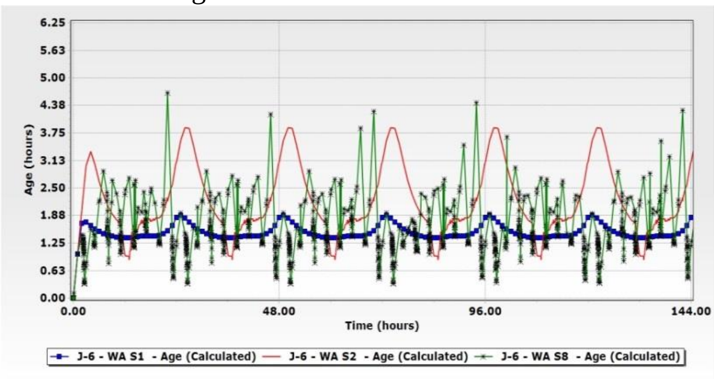


Fig. 19. Variation of water age with time at J-6 for scenarios S_1, S_2 and S_8.

4.5. Flow control

When the flow is controlled such that the pipes network is divided into suburbs with equal water demands and each suburb roof tanks fills in certain time , the needed demand during the day has no peaks. So, lower flow and head is needed to be pumped. Table (3) and Table (4) represent the new booster pump characteristics in scenarios S_9 and S_{10}, respectively.

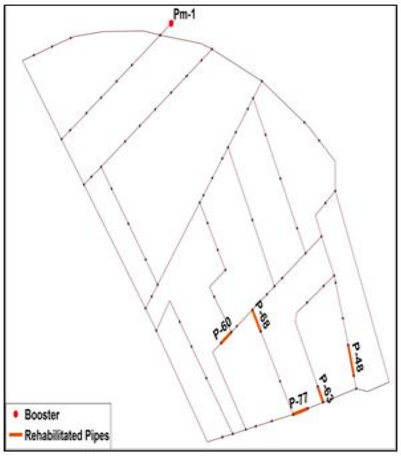
Table. 3.
New booster pump characteristics, in scenario S_9.

Flow (l/s)	Head (m)
0	24
230	18
460	0.5

Table. 4.
New booster pump characteristics, in scenario S_{10}.

Flow (l/s)	Head (m)
0	24
218	18
436	0.5

In S_9 and S_{10} some adjustments are added to the network to fulfill the Egyptian code for design of water and wastewater pipes network constraints by increasing the diameters of some pipes. Figures (20) and (21) show these adjustments in scenarios S_9 and S_{10}. However, number of pipes need rehabilitation in Scenario S_9 is very small compared with that needed in scenario S_{10} and also its diameter is smaller than that of scenario S_{10}.



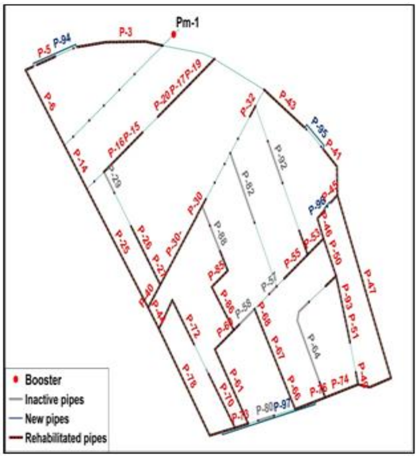


Fig. 20. Rehabilitated pipes for scenario S_9. **Fig. 21.** Inactive pipes, new pipes and rehabilitated pipes for scenario S_{10}.

Figure (22) shows the pressure head variation with time for scenarios S_9 and S_{10}. It is noticeable from this figure that, the pressure head is very near to the required pressure and also there is no high variation in pressure head between day and night. Figure (23) shows the velocity variation with time for both scenarios and it can be seen that the velocity is less than 2 m/s at any time.

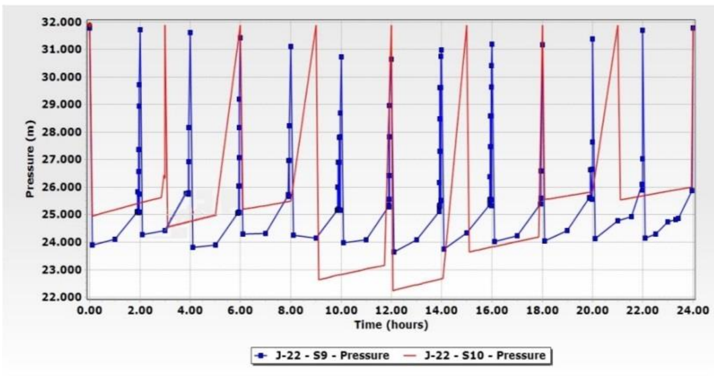


Fig. 22. Variation of pressure head with time at J-22 for scenarios S_9 and S_{10}.

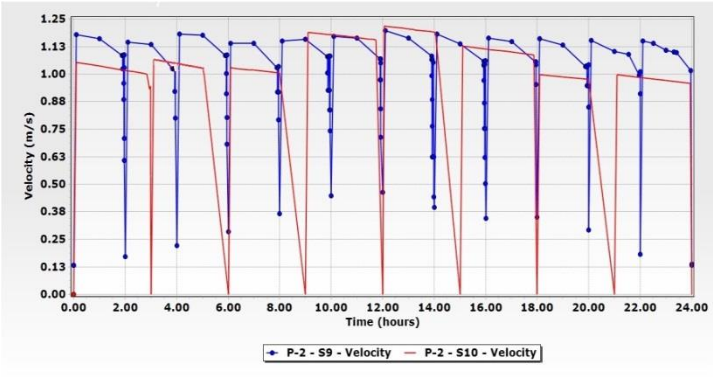


Fig. 23. Variation of flow velocities with time in pipe P-2 at scenarios S_9 and S_{10}.

5. Conclusions

The research discusses the hydraulic and water quality problems induced due to roof tanks filling process. A new planned WDN beside AL-Azhar minibus station in Assuit City was chosen as a case study. Bently WaterGEMS V8i software is applied to simulate the hydraulic performance and the water age of the WDN. The major findings of this study can be summarized as follows:

1) During the hours of filling, pressure heads in the pipes network drops to values less than the allowable limit and mean velocity in the pipes jumps to values higher than the permissible limit without regards to the time of filling.
2) Water age values vary with regard to the time of filling.
3) Filling roof tanks in successive periods, improve the network hydraulic performance and water quality.
4) Dividing the time of filling to small intervals has no remarkable effect on improving the network hydraulic performance and water quality.
5) Water stagnation in the pipes network increases with increasing the number of floors that is supplied from the roof tanks.
6) If the flow is controlled, then the needed demand during the day has no peaks. So, lower flow and head is needed to be pumped.
7) Flow control gives the best results in improving the network hydraulic performance and water quality. However, some pipes could be with larger diameters which may be costly.

So mainly, if the roof tanks aren't taken into consideration during the design of WDN, this can affect the hydraulic performance of the water supply pipes network.

Symbols

F	The pattern multiplication factor of the Egyptian code demand curve each two hour.
F_{max}	The maximum pattern multiplication factor.
H	Total energy per unit weight or total head (m).
h_L	Head loss (m).
h_p	Head gained from a pump (m).
$N_{(0-12)}$	The number of roof tanks that can be filled at any two hours during the day.
N_6	The number of roof tanks that can be filled from 11 am till 1 pm that represents the peak time.

$\frac{P}{\rho * g}$	Pressure energy per unit weight or pressure head (m).
Q_A	Maximum demand that is needed for the floors from the first till the third for all towers (m^3/s).
$Q_{avg.}$	Average demand that is needed for the floors from the first till the third for all towers (m^3/s).
Q_{in}	Total flow into node (m^3/s).
Q_{out}	Total demand at node (m^3/s).
Q_p	Flow pumped to fill these number of roof tanks (m^3/s).
Δt	Change in time (s).
$\frac{v^2}{2g}$	Kinetic energy per unit weight or velocity head (m).
ΔV_s	Change in storage volume [m^3].
Z	Elevation head [m].

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"تأثير خزانات أسطح المباني على الأداء الهيدروليكي لشبكات الأمداد بالمياه"

الملخص العربي

مع الزيادة المطردة في الكثافة السكانية و ثبوت الرقعة العمرانية، فقد اصبح الاتجاه العمراني الحديث هو استبدال المنازل القديمة بأبراج سكنية. و بذلك اصبحت البينة التحتية للمدينة تحت مجموعة من التحديات وخصوصا شبكات مياه الشرب القائمة و التي كنت مصممة لخدمة المنازل ذات الارتفاعات المنخفضة و الوحدات السكنية الواسعة. لذا؛ و في محاولة لتخطي واحدة من هذه التحديات وهي توصيل خدمة المياه الى الادوار المرتفعة من هذه الابراج، كان لابد من بناء خزانات أعلى هذه الأبراج. بحيث يتم ملأ هذه الخزانات من الشبكة الرئيسية عن طريق طلمبات خاصة بالأبراج و ذلك خلال فترات عشوائية و قصيرة، مما أثر بشكل رئيسي و سلبي على الأداء الهيدروليكي لشبكات امداد المياه.

لذا؛ و من هذا المنطلق كان لابد من عمل دراسة توضح تأثير العوامل المختلفة في عملية الملئ مثل: وقت و فترة الملئ و التحكم الإلكتروني في عملية الملئ على الأداء الهيدروليكي لشبكات امداد المياه من حيث: الضغوط و السرعات و جودة المياه داخل الشبكات. و قد تمت الدراسة على شبكة تخدم منطقة جديدة بجوار نفق الازهر بأسيوط و تم تخطيط المنطقة على شكل أبراج سكنية ذات أحد عشر دور.

و قد خلصت هذه الدراسة الى مجموعة من النتائج كان أبرزها ما يلي:

1) حدوث زيادة مفاجئة في قيم سرعات المياه داخل المواسير و حدوث انخفاض مفاجئ في قيم الضغوط بالشبكة و ذلك خلال فترات الملئ.
2) امكانية تحسين الأداء الهيدروليكي و جودة المياه في الشبكات من خلال زيادة فترة الملئ خلال اليوم، بينما تقسيم فترات المليء على مدار اليوم لم يحدث تأثيرا ملحوظا في تحسين الأداء الهيدروليكي و جودة المياه في الشبكات.
3) في حالة التحكم في عملية الملئ فإن التصرف المطلوب في الشبكة سيكون ثابتا تقريبا خلال اليوم بحيث يمكن ضخ تصرف ثابت من المياه خلال اليوم و بضغط اقل، مما يسهم في الوصول إلى أفضل النتائج بالنسبة للأداء الهيدروليكي و جودة المياه في الشبكات، و لكن هذا الأمر قد يتطلب عمل أحلال و تجديد لبعض المواسير و ذلك في حالة الشبكات القائمة.