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STUDY OF DEMAND AND PRESSURE AT THE RESIDENTIAL LEVEL IN A WATER NETWORK IN MEXICO

José Juan Villegas-León
Engineering, Architecture and Design Course, ``Universidad Autónoma de Baja California``
Ensenada, Baja California, Mexico
https://orcid.org/0000-0001-6593-1373

Darío Aranda-Pérez
Engineering, Architecture and Design Course, Universidad Autónoma de Baja California
Ensenada, Baja California, Mexico
https://orcid.org/0000-0002-8883-9921

Juan Francisco Durango-Grisales
Science and Engineering Course, Universidad del Sinú Elías Bechara Zainum, Montería, Colombia
Engineering School, Facultad de Ingeniería Civil, Universidad Pontificia Bolivariana
Montería, Córdoba, Colombia
https://orcid.org/0000-0002-4341-2377

Tatiana María Arteaga-Hernández
Science and Engineering Course, Universidad del Sinú Elías Bechara Zainum
Montería, Colombia
https://orcid.org/0000-0002-3857-0127

Alvaro Alberto López-Lambraño
Engineering, Architecture and Design Course, Universidad Autónoma de Baja California
Ensenada, Baja California, Mexico
https://orcid.org/0000-0002-7899-7985

Abstract: This work presents demand and pressure data at the residential level, in the water distribution network of the city of Ensenada, Baja California, Mexico. The demand (consumption) measurement was carried out with an ultrasonic flow meter, while the pressure measurement was carried out with an electronic manometer. The data were measured for one month, through which average values were estimated for every 20 minutes and every hour during the day. The correlation between the demand and pressure data obtained is exposed, as well as the hourly behavior of the parameters, which are compared with the data estimated with a hydraulic model in Epanet, previously obtained. The demand and pressure data presented good correlation (-0.91). Finally, the average demand values obtained in the field and with the model presented a difference of 17.6%, while the average pressure values were more similar, producing a difference of only 0.7%.

Keywords: Demand, pressure, water network, residential level, home intake.

INTRODUCTION

In the design, review, modeling and optimization of drinking water systems that supply populations, it is essential to take into account the components that make up said systems, as well as their hydraulic properties, among others. Likewise, it is essential to know the behavior of water demand and the pressure that said network must withstand, to undertake an adequate design of new systems, review of networks in operation, modeling of different scenarios with specialized software and optimization of resources. of said hydraulic systems (Saldarriaga, Páez & Vallejo, 2014). One of the parameters that most influences the hydraulic behavior of water networks is the consumption demand of users (García, García-Bartual, Cabrera, Arregui &

García-Serra, 2004). This demand for water is very common to be represented by what is known as the Hourly Variation of Demand Curve (CVHD), where its behavior depends directly on the needs and consumption habits of the entire population to which it supplies. network. However, said CVHD may differ regarding the behavior of water demand generated at the household level, given that the users supplied by each intake demand different flow rates, at different times and durations, according to their requirements (Tzatchkov, Alcocer-Yamanaka, Arreguín-Cortés & Feliciano-García, 2003).

Currently, different specialized programs are used to carry out dynamic modeling of the hydraulic behavior of water supply systems, allowing the simulation of design conditions, operating conditions and to optimize system resources, among others. In these models, it is required to provide demand information in the nodes of the system, which can represent one or a set of household outlets; Therefore, it is essential to know the demand for water at this level (Tzatchkov & Alcocer-Yamanaka, 2016). In recent decades, efforts have been invested in the investigation and monitoring of Residential Demand (DNR) of various water distribution networks (Cominola, Giuliani, Piga, Castelletti & Rizzoli, 2015), where valuable information is obtained for users. hydraulic models, as well as to generate synthetic DNR data of the systems, using various methodologies such as those used in Koutiva & Makropoulos (2016); Mostafavi, Gándara & Hoque (2018); Mostafavi, Shojaei, Beheshtian & Hoque (2018); and in Pan et al. (2020).

On the other hand, among other uses, the data obtained from measurements of Pressure at Residential Level (PNR), in a water distribution system (among other points of interest), are used to calibrate the hydraulic models of said systems, which It consists of adjusting the measured pressure data against the data estimated by the model (Giustolisi & Berardi, 2011); as has been carried out in various works such as those recently reported by Abu-Mahfouz et al. (2019); Mentes, Galiatsatou, Spyrou, Samaras & Stournara (2020); Milkecha & Itefa (2020); and Wéber & Hos (2020).

Based on the above, the importance of investigating the behavior of water demand and pressure at the residential level is highlighted. Accordingly, the main objective of this study is to obtain information from the DNR and the PNR, in the water distribution network of the city of Ensenada, Baja California, Mexico. The Materials and Methods explain the study location, the devices used for measurements, as well as the methodology used for this. The Results and Discussions present tables and graphs of demand and gauged pressure, correlation graphs between demand and pressure obtained at the residential level, as well as comparison graphs of demand and pressure measured in the field, against results estimated with a model. previously calibrated hydraulic. Finally, the Conclusions and References are presented.

MATERIALS AND METHODS

Figure 1 illustrates the point where the flow and pressure measurements were carried out, which was at a residential-type home intake, in the Empleados neighborhood of the City of Ensenada, B.C., Mexico. This household intake corresponds to the water supply network of the central sector of the City.

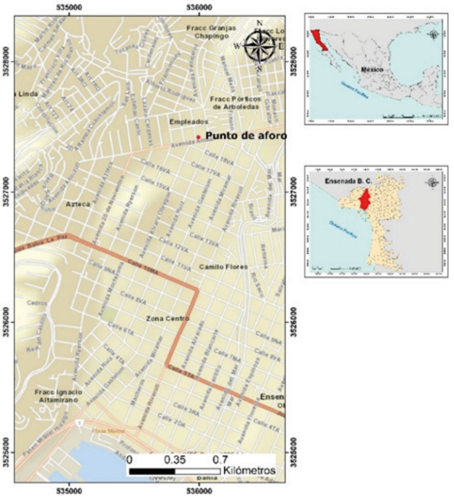
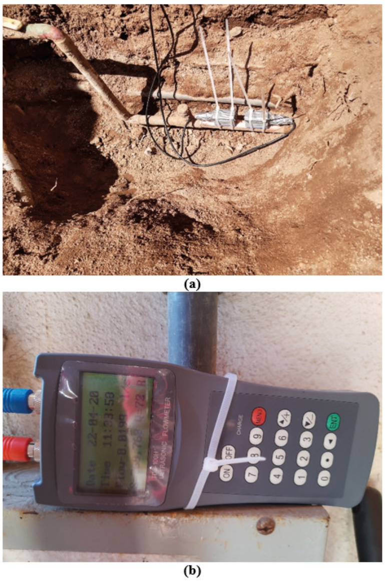


Figure 1.- Location of the flow and pressure measurement point at the residential level.

Figure 2 shows the installation of the ultrasonic flow meter that was used to obtain the flow behavior at the residential level. The equipment used for this consisted of a pair of transducers for pipes from 0.5 to 4.0 inches (figure 2a), as well as the TDS100H model recorder (figure 2b).



(a)

(b)

Figure 2.- Installation of the flow meter in a residential type household outlet. a) Pair of transducers. b) Ultrasonic flow recorder.

On the other hand, Figure 3 shows the installation of the electronic manometer used to record pressures at the residential level. This equipment is Dickson brand, model PR325, with a pressure range of 0 to 300 PSI.

Figure 3.- Installation of the electronic pressure gauge on a garden faucet in the residential type household outlet.

On the other hand, to achieve the objective of this research, the following methodology was followed: First, the residential water intake where the flow and pressure gauging would be carried out was analyzed and defined. With this, it had to comply with the accessibility for the installation of the equipment and its security, as well as the availability and permission for the review and extraction of data. Then the ultrasonic flow meter and the electronic pressure gauge were installed, taking into consideration the technical indications for this. Once the equipment was installed, the relevant programming was carried out to obtain flow and pressure records every 20 minutes. Data monitoring was carried out for one month. From the records obtained, averages of flow rates and pressures were estimated every 20 minutes during the day, which are presented through tables and graphs. With this, the correlation between the demand and pressure data obtained at the residential level was determined. Finally, hourly data of the demand flow and pressure were obtained, which are compared using graphs, with the data estimated with a previously calibrated hydraulic model in Epanet.

RESULTS AND DISCUSSIONS

Table 1 contains the average DNR flow data, which were obtained for every 20 minutes during the day. In this you can visualize the variability of said demand flow for each indicated time, where the minimum flow is 0.0065 Liters/s (lps) at 10 minutes, while the maximum or peak flow is 0.054 lps and was presented at 690 minutes a day.

Time [min]	Flow [lps]	Time [min]	Flow [lps]	Time [min]	Flow [lps]
10	0.0065	490	0.0423	970	0.0416
30	0.0169	510	0.0511	990	0.0397
50	0.0172	530	0.0500	1010	0.0418
70	0.0158	550	0.0359	1030	0.0441
90	0.0137	570	0.0454	1050	0.0512
110	0.0150	590	0.0506	1070	0.0464
130	0.0156	610	0.0454	1090	0.0467
150	0.0147	630	0.0500	1110	0.0424
170	0.0158	650	0.0496	1130	0.0430
190	0.0135	670	0.0489	1150	0.0375
210	0.0177	690	0.0540	1170	0.0332
230	0.0172	710	0.0328	1190	0.0264
250	0.0168	730	0.0519	1210	0.0466
270	0.0174	750	0.0537	1230	0.0368
290	0.0291	770	0.0499	1250	0.0341
310	0.0139	790	0.0483	1270	0.0322
330	0.0162	810	0.0386	1290	0.0252
350	0.0253	830	0.0361	1310	0.0255
370	0.0384	850	0.0392	1330	0.0215
390	0.0226	870	0.0463	1350	0.0264
410	0.0341	890	0.0410	1370	0.0251
430	0.0316	910	0.0466	1390	0.0174
450	0.0310	930	0.0521	1410	0.0181
470	0.0443	950	0.0443	1430	0.0086

Table 1.- Average values of demand flows at the residential level, obtained every 20 minutes during the day.

From the values indicated in Table 1, Figure 4 was prepared, which illustrates the behavior of the average values of DNR flow rates, with respect to consumption time (every 20 minutes during the day). There it can be clearly seen that demand develops oscillations over time, presenting a stochastic behavior. However, we can assume that the highest demands occur from 510 to 1050 minutes of the day, while the lowest demands originate between 1390 and 270 minutes of the day.

On the other hand, Table 2 shows the average PNR data, which were obtained for every 20 minutes during the day. In this table you can analyze the pressure for each indicated time, where the minimum pressure is 46.84 meters of water column (mca) and is generated at 1090 minutes, while the maximum pressure is 53.04 mca and is produced at 230 minutes of the day.

Time [min]	Pressure [mca]	Time [min]	Pressure [mca]	Time [min]	Pressure [mca]
10	52.72	490	48.26	970	49.21
30	52.78	510	48.24	990	49.45
50	52.86	530	48.09	1010	48.24
70	52.91	550	48.13	1030	48.40
90	52.95	570	47.83	1050	48.50
110	52.96	590	47.52	1070	47.43
130	52.92	610	47.78	1090	46.84
150	52.87	630	47.61	1110	47.67
170	52.87	650	47.88	1130	49.33
190	52.92	670	47.64	1150	49.81
210	52.86	690	47.91	1170	50.22
230	53.04	710	47.66	1190	50.16
250	52.69	730	47.91	1210	50.56
270	52.59	750	48.07	1230	50.72
290	52.30	770	48.21	1250	50.60
310	52.02	790	48.64	1270	51.19
330	51.74	810	48.27	1290	51.51
350	51.25	830	48.79	1310	51.62
370	50.72	850	48.87	1330	51.94
390	50.39	870	49.27	1350	52.14
410	49.83	890	49.29	1370	52.27
430	49.26	910	49.08	1390	52.44
450	49.24	930	48.82	1410	52.55
470	48.48	950	49.18	1430	52.61

Table 2.- Average pressure values at the residential level, obtained every 20 minutes during the day.

Based on the information in the previous

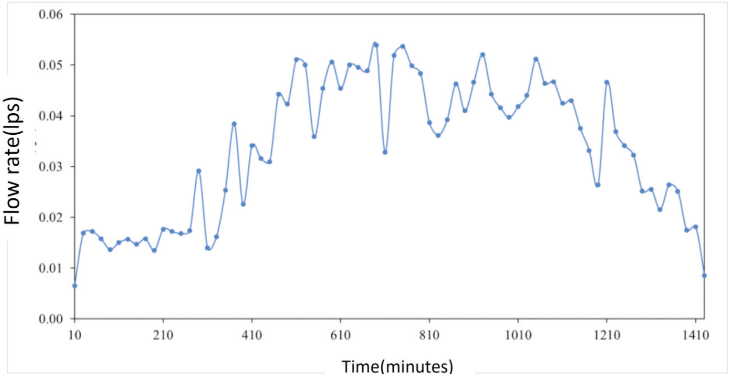


Figure 4.- Behavior of average values of demand flows at the residential level, with respect to every 20 minutes during the day.

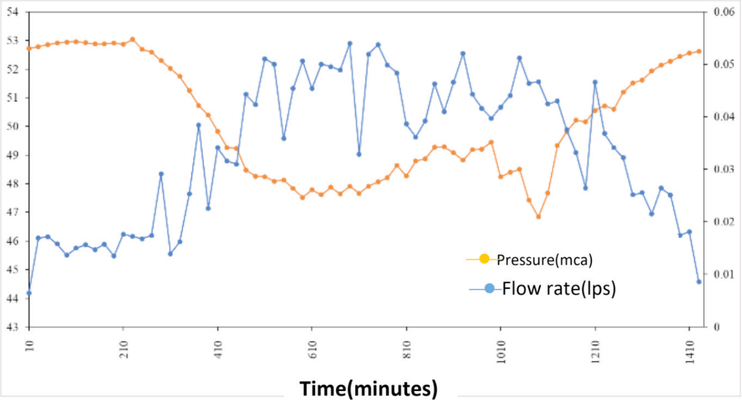


Figure 6.- Contrast of DNR and PNR data, in relation to the field registration time (every 20 minutes).

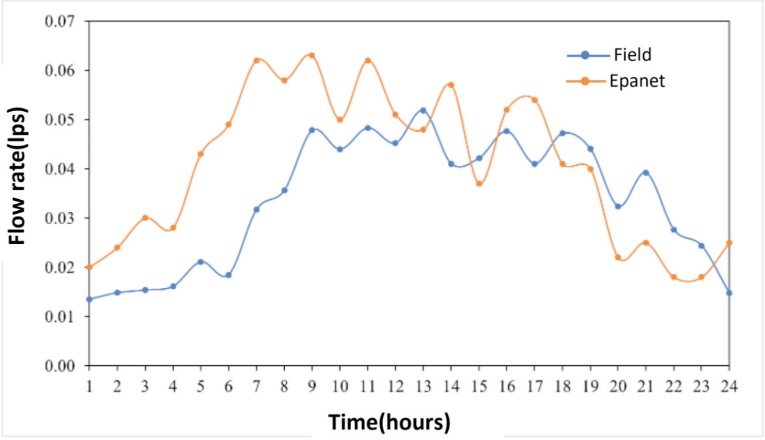


Figure 8.- Comparison of the hourly variation curve of the DNR, obtained with field data and with data estimated with a hydraulic model in Epanet.

table, Figure 5 shows the average PNR procedure, according to every 20 minutes during the day. In this figure you can see the trend that the pressure follows, as well as that high pressures occur in the first minutes of the day (10 to 310 minutes), while low pressures occur approximately between 530 and 1130 minutes.

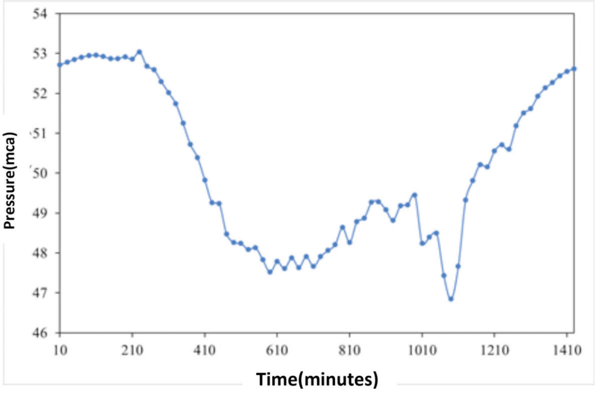


Figure 5.- Behavior of average pressure values at the residential level, with respect to every 20 minutes during the day.

Based on the DNR and PNR data, Figure 6 shows a contrast of the behavior of these data, according to the recording time in the field (every 20 minutes). It can be seen that, in general, the lower the flow rate, the higher the pressure and vice versa. However, the flow trend with respect to time is more inconsistent than the pressure behavior.

Figure 7 shows the correlation of the data measured in the DNR and PNR field, which was -0.91. This indicates that there is good correlation in the data investigated, however, this could be improved by averaging the data obtained with more records at other points of the network at the residential level, as well as expanding the days of data collection.

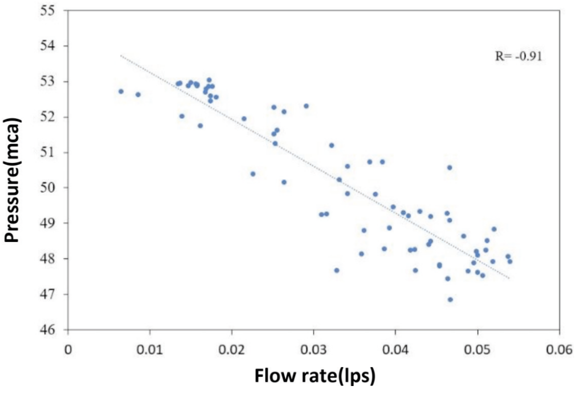


Figure 7.- Correlation of data measured in the field on DNR and PNR.

On the other hand, Figure 8 shows a comparison of the Hourly Variation Curve of Demand at the Residential Level (CVHDNR), which has been determined with the information measured in the field, compared to a CVHDNR obtained with estimated data from a hydraulic model, previously calibrated with pressure data. Mainly, we can notice that the demand generated with the model was higher in most hours. Likewise, it is illustrated that there is consistency in the data from 6 to 11 p.m., where the demand recorded in the field is highest. Finally, analyzing all this information, the average demand flow measured in the field is 0.034 lps, while the average demand given by the model is 0.041 lps, generating a difference of 17.6%. This opens the way to take advantage of this information to continue improving the hydraulic model.

In Figure 9, a comparison of hourly values obtained in the field is also made against those estimated with the aforementioned hydraulic model, but in this case it is based on PNR information. In this figure it can be seen that the pressures given by the model are more inconsistent, presenting a series of fluctuations, while the pressures measured in the field show a more defined trend. Furthermore, it is shown that in the period from 10 p.m. to 3 p.m., a continuous majority occurs in the pressure values generated with the hydraulic model. However, in the period from 4 a.m. to 9 p.m., an exchange occurs in the highest and lowest pressure values for the hours between said period. Finally, considering all this information, the average field pressure is 50.13 mca, while the average pressure of the model data is 50.49 mca, producing a difference of 0.7%. According to this result and what was established by Cheng & He (2011), and by Kapelan, Savic, & Walterrs (2007), it appears that the hydraulic model adequately represents the pressure data in the field, which is why it is considered calibrated. and good to use in the hydraulic analysis of any scenario.

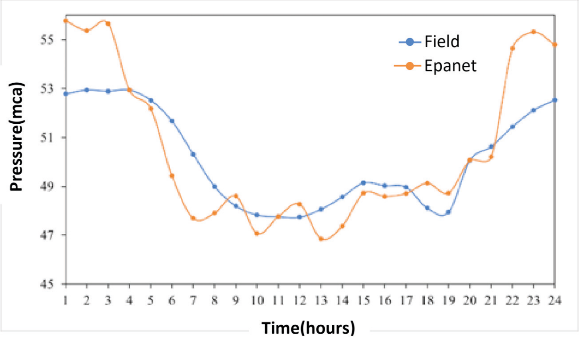


Figure 9.- Comparison of the hourly pressure curve at the residential level, obtained with field data and with data estimated with a hydraulic model in Epanet.

CONCLUSIONS

DNR and PNR information was obtained in a home survey in the downtown sector of the city of Ensenada, B.C. Mexico, according to times of 20 minutes during the day. The minimum flow was 0.0065 lps at 10 minutes, while the maximum flow was 0.054 lps and occurred at 690 minutes of the day. Regarding pressure, the minimum value occurred at 46.84 mca at 1090 minutes, while the maximum pressure was 53.04 mca and occurred at 230 minutes of the day. It was found that the flow behavior was more inconsistent with respect to time, presenting more fluctuations compared to pressure. However, the correlation between the DNR and PNR data was -0.91, which indicates that there is a strong correlation between these parameters, which could be improved by obtaining more records in other residential points, as well as increasing the number of days for information collection. A comparison of DNR and PNR hourly results was also presented, based on information obtained in the field and estimated with an Epanet hydraulic model. In this case, the behavior of the demand flows were less similar, presenting a difference of 17.6% in the average values. However, the pressures were more similar, producing a difference of only 0.7% in the average values. Finally, it is worth highlighting the great usefulness of the information presented on DNR and PNR, to apply it to improve the operational functioning of the aforementioned water distribution network. CVHD of water supplied by the Morelos tanks to residents of Ensenada were obtained for each day of the week. In general, these curves presented a similar trend, however, analyzing the average flows, the maximum flow occurs on Sunday with 299 lps, while the minimum flow occurs on Saturday with 273 lps.

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