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HOURLY VARIATION CURVE OF WATER DEMAND FOR SECTORS OF ENSENADA, B.C.

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Abstract: In this work, hourly demand curves (CVHD) are obtained in the water distribution network in the downtown area of the City of Ensenada, B.C., Mexico. For this, hourly historical records of the hydraulic stays and inlet flows in the Morelos tanks and the Keki tank were obtained. With this, average hourly supply flows were estimated for each day of the week, then average demand flows were calculated for each hour of the day, allowing a graph of the CVHD supplied by each tank to be obtained. It was found that the peak demand for the Morelos tanks occurs at 9 hours with a flow of 378 lps, while the minimum demand occurs at 3 hours with a flow of 170 lps. In the Keki tank, the peak demand occurs at 12 hours with a flow rate of 80 lps, while the minimum demand is also generated at 3 hours, but with a flow rate of 33 lps. Finally, the CVHD obtained are very useful in hydraulic models for the review and analysis of operational improvement in drinking water networks.
Keywords: Demand curve, hydraulic modeling, supply network.

INTRODUCTION

It is of great importance to know the behavior of the demand for water in the supply networks to the populations, because with this it is possible to appreciate and analyze the dynamism of its interannual, seasonal, weekly, daily and hourly variations (Tzatchkov & Alcocer- Yamanaka, 2016). This behavior is represented by what is known as the hourly variation curve of demand (CVHD), which makes it possible to identify, among other things, the hours of greatest and least consumption of the population. With this, information is obtained for improvements in planning, operation and design of these water distribution systems (Alcocer-yamanaka, Arreguín-cortés, & Feliciano-garcía, 2003; Tzatchkov & Alcocer-Yamanaka, 2016), where simulations are commonly used. dynamics with models obtained in programs such as EPANET, infoWorks and scadRED (Arreguín, Alcocer-Yamanaka, & Hernández-Padrón, 2010).

The CVHD is essential to be able to carry out dynamic simulations of the hydraulic behavior of water networks, because from this demand patterns are defined that are provided to the computational models. However, it is complex and expensive to collect the information to determine said CVHD, since instrumentation and specialized personnel in flow gauging are required, for which reason said curve is lacking in water supply systems. However, in recent years, studies with different purposes have been reported, where CVHD has been obtained or defined using different methods, some of which are cited below. Tzatchkov & Alcocer-Yamanaka, (2016) proposed a methodology to obtain the daily variation of the instantaneous demand for drinking water, which is applicable to a single house or any number of houses based on the statistical parameters of water consumption in houses. individual, given level of leaks and the variation of the cost measured in the supply pipe, considering cases of continuous and intermittent supply. Letting, Hamam & Abu-Mahfouz, (2017) carried out a study in a water network, where they obtained the behavior of the hourly demand in some nodes and pipes of the system, using the particle swarm optimization (PSO) algorithm. acronym in English). Anele, Hamam, Abu-Mahfouz & Todini, (2017) evaluated different methods for forecasting short-term water demand, finding that the ARMA, ARMAX and hybrid models can be considered the best for predicting future demands. Shabani, Candelieri, Archetti & Naser, (2018) proposed a new approach to short-term water demand forecasting in the city of Milan, Italy, based on a two-stage learning process that combines series clustering. of time with gene expression programming. Finally, Mentes, Galiatsatou, Spyrou, Samaras & Stournara, (2020) developed a hydraulic simulation model for the aqueducts of the city of Thessaloniki in Greece, where they obtained the hourly demand of the different areas that make up the system, using information such as from records of storage tank levels, from flow meters and from theoretically estimated data.

The works mentioned above, show the importance of this subject for knowing the demand for water supplied to the populations, as well as showing the different techniques used to estimate the CVHD, which essentially depends on the consumption information that is obtained. have in the systems.

Based on the above, the purpose of this work is to obtain the CVHD of water supplied by the Morelos tanks and the Keki tank to the hydraulic network of the city of Ensenada, B.C., Mexico. For this, historical records of the water levels in the mentioned tanks are used, as well as the inflows to these.

MATERIALS AND METHODS

The Morelos tanks are located in Col. Loma Linda, in the city of Ensenada, B.C. (Figure 1), which are planted at an elevation of 249 meters above sea level (masl). This storage system is made up of 2 cylindrical tanks with a diameter of 32.5 m and a height of 9.15 m, presenting an approximate water storage capacity of 15,000 m3 with both tanks. These tanks are the main ones in the city's water distribution system, supplying an average flow of 288 lps, to an approximate population of 144,000 inhabitants, through a discharge pipe of 457.72 mm in diameter (18 inches).

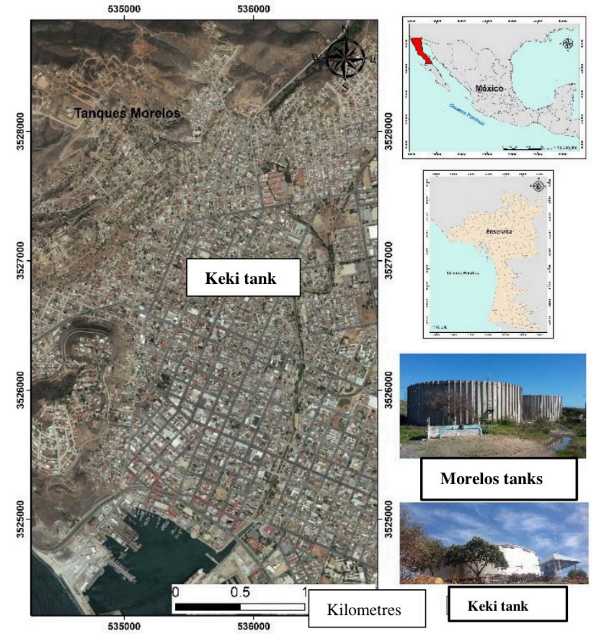

Figure 1.- Location of Morelos tanks and the Keki tank in the city of Ensenada, B.C.

On the other hand, the Keki tank is located in the Zona Centro neighborhood, planted at an elevation of 68.37 masl, it has a cylindrical structure with a diameter of 20.00 m and a height of 6.00 m, generating a storage capacity of close to 1,890.00 m3. Said tank is fed from the Morelos tanks with an average flow of 60 lps, which are distributed to an approximate population of 21,608 inhabitants, through 2 pipes of 254.00 mm in diameter (10 inches).

Both the Morelos tanks and the Keki tank distribute water by gravity, have a telemetry system, through which water levels are measured and recorded, which are monitored from a Central. Likewise, there are macrometers that are used to measure the inflows to each of these storage systems.

On the other hand, the determination of the CVHD that supplies the tanks under study, was carried out following the following procedure.

1. For each day of the week, the hourly historical records of the hydraulic stays were obtained, as well as the inlet flows in said

tanks, information that was provided by the Ensenada State Public Services Commission.

2. With the data collected in the previous point and knowing the geometry of the tanks, the average flows supplied in relation to the water demand for each day of the week were analyzed and estimated.

3. From the flows obtained in point 2, the average demand flows were calculated for each hour of the day on the information of the days of the week.

4. Finally, the CVHD of water that supplies each analyzed tank was prepared.

RESULTS AND DISCUSSIONS

This section presents the results obtained for the elaboration of the CVHD of the Morelos tanks, product of the aforementioned methodology. However, only the final product of the CVHD behavior of the Keki tank is presented, which is contrasted with that of the Morelos tanks.

Table 1 shows the flows supplied from the Morelos tanks to the hydraulic network, corresponding to the hours of the day for the seven days of the week.

Average flows (lps)							
Hour	**Sun.**	**Mon.**	**Tue.**	**Wed.**	**Thu.**	**Fri.**	**Sab.**
1	204	151	241	174	162	166	224
2	239	323	222	204	158	62	187
3	191	151	208	146	190	117	190
4	181	181	190	167	199	169	176
5	205	174	241	167	248	141	183
6	256	244	333	246	281	203	253
7	320	275	315	283	345	264	294
8	353	309	359	315	345	324	320
9	383	400	364	369	367	375	391
10	344	395	312	373	433	412	373
11	366	332	314	387	396	355	358
12	378	331	302	392	381	353	319
13	333	341	339	378	457	336	312
14	474	354	307	378	305	346	376
15	301	401	284	364	355	418	233
16	372	378	300	419	310	364	316
17	340	348	258	352	327	341	284
18	319	306	263	357	319	304	268
19	292	343	310	352	276	386	271
20	297	258	303	285	299	289	268
21	301	332	236	264	274	317	238
22	290	191	176	232	264	252	199
23	225	288	296	267	214	213	252
24	220	239	122	287	196	166	268
Prom.	299	294	275	298	296	278	273

Table 1.- Hourly flow rates supplied from the Morelos tanks for the days of the week.

In the information in the previous table, it can be seen that the hourly flows are different for each day of the week, except for the 4 hours of Sunday and Monday, where it coincides at 181 lps. However, analyzing the daily average flows, approximate values are presented on Sunday, Monday, Wednesday and Thursday, as well as on Tuesday, Friday and Saturday. Finally, it can be noted that the average minimum demand occurs on Saturday with 273 lps, while the maximum occurs on Sunday with 299 lps.

On the other hand, Figure 2 graphically shows the flows shown in Table 1, where a similar behavior can be seen in general for the 7 days of the week. It is observed that the hours of least consumption correspond to the morning and range from 1 to 5 a.m., with Friday being the lowest demand with 62 lps at 2 a.m. of the day. It is also illustrated that from 6 a.m. to 9 a.m. there is a gradual increase in demand for every day. However, it must be noted that from 9 a.m. to 4 p.m. is when the highest demand flows occur, with a maximum of 474 lps on Sunday. Finally, after 5:00 p.m. until the end of the day, the demand tends to decrease.

Figure 3 shows the behavior of the CVHD that supplies the Morelos tanks, where it can be seen that from 1 to 5 hours the demand oscillates between 170 and 199 lps. Likewise, it is shown that from 5 o'clock the demand increases, until it reaches close to 378 lps at 9 hours of the day. It can be noticed that the hours of greatest demand are at 9, 10 and 14 hours. It is also observed that from 3:00 p.m. the demand flow decreases and presents oscillations, until reaching 214 lps in the 24 hours of the day. Finally, it must be noted that the minimum demand flow is 170 lps and occurs at 3 hours, while the peak demand flow is 378 lps and occurs at 9 hours a day, generating an hourly average demand flow of 288 lps.

Figure 4 shows the behavior of the CVHD supplied by the Keki tank, which was obtained from information similar to that presented in this section on the Morelos tanks. In the aforementioned figure, the behavior of both CVHD of the mentioned tanks is contrasted, where it can be seen that the behavior of both curves is similar, but in different magnitudes. The Keki tank supplies an average of 60 lps, which represents approximately 21% of the 288 lps distributed from the Morelos tanks.

Regarding the Keki tank, the flows with the highest demand occur at approximately 9, 12 and 15 hours, with the peak demand flow of 80 lps occurring at 12 noon, while in the Morelos tanks it is generated at 9 hours. Lastly, it must be noted that the minimum demand flow is 33 lps and occurs at 3 hours a day, coinciding with the time of the Morelos tanks.

CONCLUSIONS

CVHD of water supplied by the Morelos tanks to the inhabitants 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.

From the hourly flows of average demand for the days of the week, CVHD of water that supplies the population from the Morelos tanks and the Keki tank was determined, which showed a similar behavior on the plane, representing approximately 21% of the average flow distributed by the Keki tank, over the flow provided by the Morelos tanks. In the estimated curve for the Morelos tanks, it was noted that the peak demand occurs at 9 hours with a flow of 378 lps, while the minimum demand occurs at 3 hours with a flow of 170 lps. However, in the curve obtained for the keki tank, the peak demand occurs at 12 hours with a flow of 80 lps,

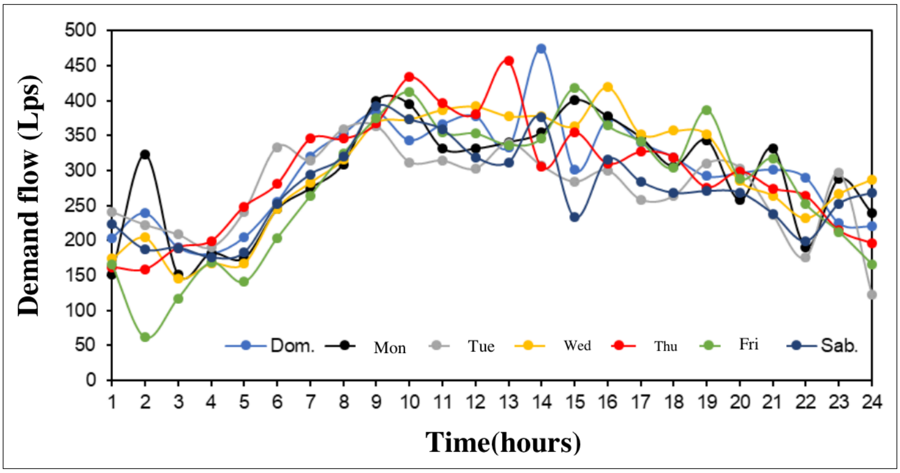

Figure 2.- Behavior of the hourly flows supplied from the Morelos tanks for the days of the week.

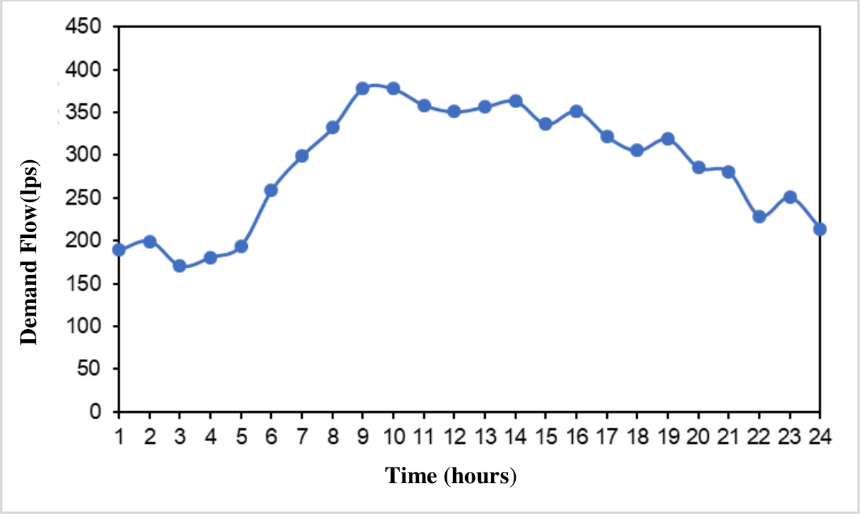

Figure 3.- CVHD of the population that the Morelos tanks supply.

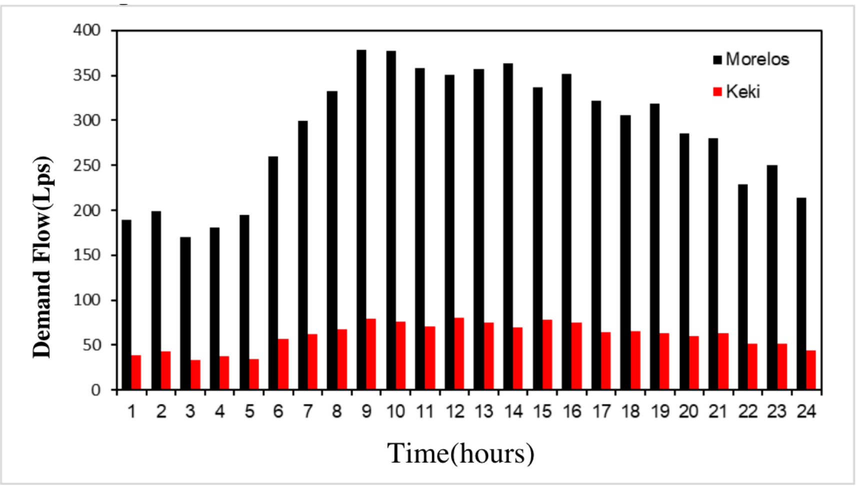

Figure 4.- CVHD of the population supplied by the Morelos tanks and the Keki tank.

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while the minimum demand is generated at 3 hours (the same as in the Morelos tanks), with a flow of 33 lps.

Finally, the CVHD obtained in the present study are a highly advantageous tool for the review and analysis of operational improvement in the drinking water systems of the city of Ensenada. The aforementioned curves also allow us to appreciate and analyze their hourly variations, providing, among others, the critical hours of water demand (maximum and minimum), resulting in very useful information for the administrators of these hydraulic systems to plan to guarantee demand and continuity. of service. Likewise, from these curves the creation of dynamic hydraulic models can be achieved, through which the hydraulic behavior of real systems is studied, under different operating scenarios.

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