International Journal on Emerging Technologies **12**(2): 01-08(2021)

ISSN No. (Print): 0975-8364
ISSN No. (Online): 2249-3255

A Study of Urban Domestic Water Service Delivery through User Perspective Survey

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(Received 25 December 2020, Revised 05 March 2021, Accepted 30 March 2021)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: **An accurate knowledge of water services delivery performance as experienced by users is of vital importance for monitoring & evaluation of existing drinking water supply systems which in turn would help devise focused strategies aimed at improving the service delivery. Currently, there is a lack of systematic assessment of urban water utilities in urban areas of some developing countries. Operations of services and maintenance activities are more of a reactive nature whereby actions are taken in response to customer complaints. Current reactive approach is inherently inefficient as well as makes it almost impossible to move towards sustained improvement in quality of service. This study seeks to bring out users' perspectives on quality and quantity of water supply services which shall inform strategic plans formulation by the utilities. The aim of this research study is to ascertain the level of domestic water services for an urban township and to qualitatively assess the condition and operationalization of existing water supply systems in the study area. In this study we obtain the users' feedback about water quality, quantity, duration of daily delivery, terminal pressure, water conservation, willingness to install water metering system and willingness to pay for the drinking water supply through a questionnaire-based User Prospective Survey. This study concludes that the existing water supply schemes are critically over stressed and are unable to meet the domestic water demand of the households. The terminal pressure at the household level is so low that 42% of the households have indulged in illegal fetching of water through suction pumps. The overall quality of municipal water was reported to be fit for drinking by 91% of the households while others relied mostly on bottled water. Moreover, 29% households were willing to install water meters while 71% wanted the current flat rate billing system based on the house size. With the availability of user's feedback about service delivery issues, one can rank the performance of existing water supply systems and move towards designing a 24/7 Water Supply System.**

Keywords: Contamination, Condition assessment, Intermittent, Questionnaires, Service delivery,

Abbreviations: NIUIP, National Institute of Urban Infrastructure Planning; HH, Household; PKR, Pak Rupees; US$, United States Dollar, RCC, Reinforced Cement Concrete.

I. INTRODUCTION

Water is an essential component for the socio-economic advancement of any country in the world. It plays an essential role in ensuring sustainable life of all living things on earth [1]. Water is the baseline for the social, economic, and agricultural activities of a country. It is mostly used for domestic, agricultural, industrial and food production activities [2]. Urban domestic water requirements of an urban family are mostly for their different household activities like drinking, cooking, bathing, washing floors, washing utensils in kitchen, laundry and irrigating gardens and plants [3]. Communities all around the world have come to know that the unnecessary and unreasonable consumption of water are not at all acceptable [4]. Because of these reasons, water service delivery has turn into an essential tool for the assessment, functioning, and managing of a water supply system. It is needed for activities like extension of existing schemes of water supply, evaluating the capacities and operation of water storage reservoirs, pumping machineries, treatment plants, pump houses, pipeline and supply main sizes, water pricing policies and practices and water use limitations [5].

Due to increase in world population and economic advancement, residential water requirements have been increasing globally [6]. Studies pertaining to domestic water consumption and service delivery develop a sense of ownership and accountability in the households towards their behavior in using municipal water. Moreover, these research studies and surveys help the government and municipalities to assess the high and low revenue generation areas as well as to know about internal system leakages [7].

This research study emphasizes on the household's feedback through questionnaire regarding quality, quantity, duration, uses, water conservation, water metering system and service delivery of municipal water supply in an urban setting of Peshawar, Pakistan.

II. METHODOLOGY

A. Study area description

This research study has been carried out on a sample of 76 urban houses of various sizes, located in Hayatabad township of Peshawar, Pakistan. The total population of

the township is 191,313 persons and 24,923 household [8]. The township is subdivided into various zones (or sectors) based on plot sizes, which can be considered an indirect measure of the socio-economic status of the households. The number of sampled households in various zones based on the house size are given in Table 1.

B. Development of Questionnaire

A questionnaire was designed and distributed among households of the township to obtain user's opinion regarding water use for various household activities including drinking, bathing, kitchen use, washroom floors, gardening, and other uses.

Additional questions were included in the questionnaire so that added information about water quality, quantity, uses, conservation, terminal pressure, internal leakages, water storage capacities, water charges, water metering, willingness to pay, willingness to install equipment and complaint frequency as well as response time of utility company/department could be asked from the domestic consumers.

Households were also interviewed about some basic information like household sizes, number of additional occupants/guests/servants, number of bed rooms, kitchens, toilets and servant rooms, level of education of the head of the households and their spouses, household monthly income ranges, time of washing clothes in hours per day, number of times the utensils are washed in their kitchens and how much time (minutes per day) the water tap remains open for the said purpose, size, location and type of water tanks, number of pumping hours, time of pumping water from underground tanks to overhead tanks, sizes and types of washable floors, sizes and number of irrigatable lawns and number of washable cars/motor bikes using municipal water at home.

C. Data Collection and User's Response

Group discussions and individual meetings were carried out with head of households after serving the questionnaires to the targeted 82 residents of urban housing units. The said exercise remained continued for more than three months. As a result of extensive field work, 76 out of 82 households (93%) responded to the questionnaires.

D. Existing Conditions of Targeted Houses

Demographic Details. The targeted urban houses were divided into five categories, i.e. A, B, C, D and E based on their house sizes.

Table 1: Categories on the basis of house size.

Category	Size (Sq Ft)	Sample Size
A	8700	6
B	5500	19
C	2683	15
D	1361	9
E	953	27
Total		76

Existing Water Supply Systems. Existing water supply system in targeted houses is one of intermittent supply systems where water is being pumped by public tube wells thrice a day for a total period of 10 hours per day. Water is either stored in ground/underground water tanks of houses or pumped directly to overhead water tanks depending upon the location of house from water source. Sizes of the water tanks vary with the house size.

Existing Water Storage Facilities. Underground water storage facilities were not considered in the design of Category –A and Category-B houses but later constructed by the households at their own when they faced water shortages. Houses in Category-C and D have only overhead water storage arrangements. Category-E were designed to get water from combined water storage tanks, but said tanks have now become abundant and therefore, households have made their personal storage arrangements inside their houses through extra water tanks.

Volumes and Condition of Water Tanks. The overhead water tanks in the targeted houses were initially constructed of Reinforced Cement Concrete (RCC).Later on in few houses fiber glass tanks were placed by the households because RCC tanks were either non-functional or insufficient to cater for their domestic water needs. In some houses, fiber glass tanks have been arranged by households and placed as ground water storage facility.

Pumping arrangements. Pumps are installed in the vicinity of the underground or surface water tanks. Houses where terminal pressure is insufficient, households have installed suctions or reciprocal pumps which are used to pull water from supply mains, and then pump the same to the overhead tanks. In 82% of the houses, water is pumped by the households from underground water tanks to overhead water tanks whereby bearing the cost of dual pumping.

E. Income group classification of targeted houses

For data acquisition with regards to User's Perspective, surveyed houses were further classified into high, medium, and low –income groups based on the household monthly income ranges.

III. RESULTS AND DISCUSSIONS

The following results have been derived from the user perspective survey.

Household Sizes & Composition. Total households in the interviewed 76 number of houses including average number of regular coming guests per month are 898 with an average size of 12 persons per house.

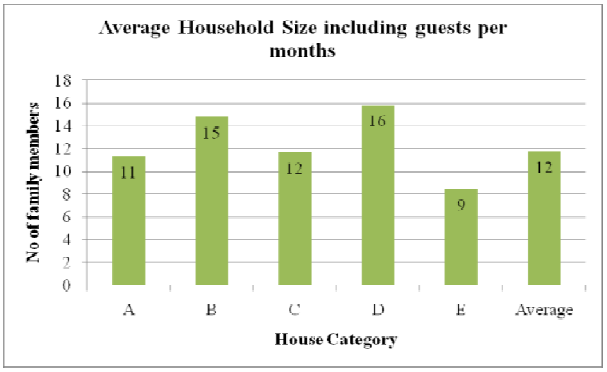

Fig. 1. Average Household Size including guests per month.

Out of total 898 households, permanent family members residing in the targeted houses are 501 (56%) with an average family size of 7 persons per house while

average numbers of regular coming guests per months are 397 (44%).

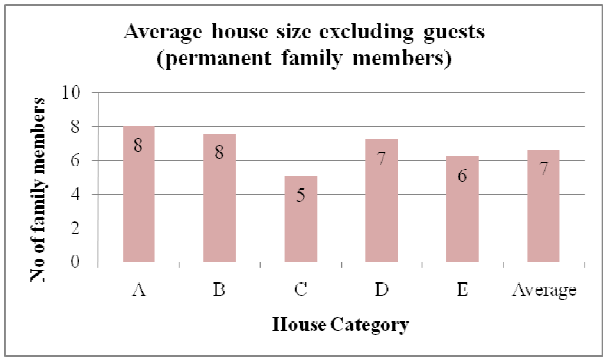

Fig. 2. Average Household Size excluding guests per month.

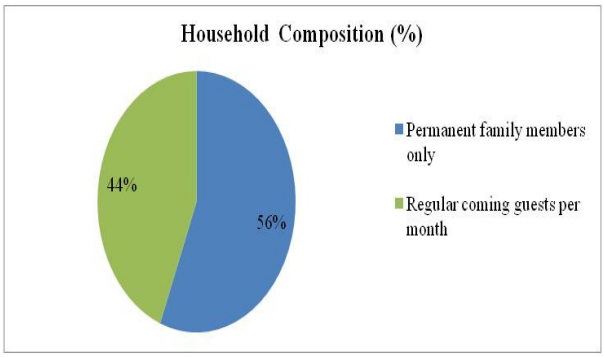

Fig. 3. Household Composition- Total HH (%).

Household Monthly Income Ranges. 51% households fall in low-income range with monthly income between PKR 25,000 (US$150) to PKR 50,000 (US$300), 37% were found in medium income range with monthly income from PKR 50,000 (US$300) to PKR 175,000 (US$1,050) whereas 12% were in high income range with monthly income from PKR 175,000 (US$1,050) and above). The survey results have revealed that the household average monthly income was PKR 80,809 (US$ 487).

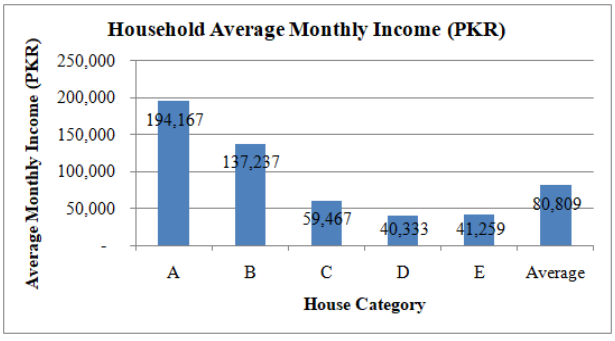

Fig. 4. Household Average Monthly Incomes.

Education Level of heads of Households. Results related to education level of heads of households have revealed that about 87% heads of houses have studied from metric (10th Grade) to masters' level while; remaining 13% are either illiterate or have studied till 8th grade.

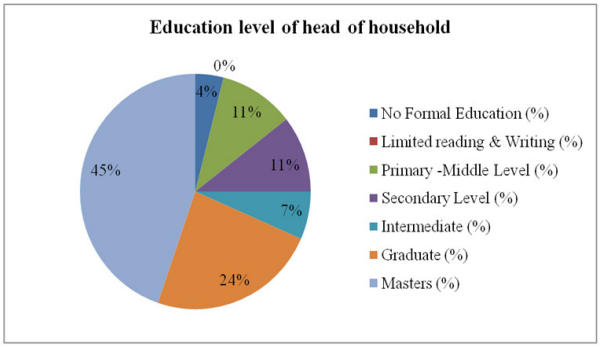

Fig. 5. Education level of Heads of households (%).

Education Level of Spouses of Households. 40% spouses of households have either no formal education or have acquired limited reading or writing skills whereas remaining 60% were educated housewives who have studied from grade 5th till master level, 50% of which have acquired bachelor's or master's degrees.

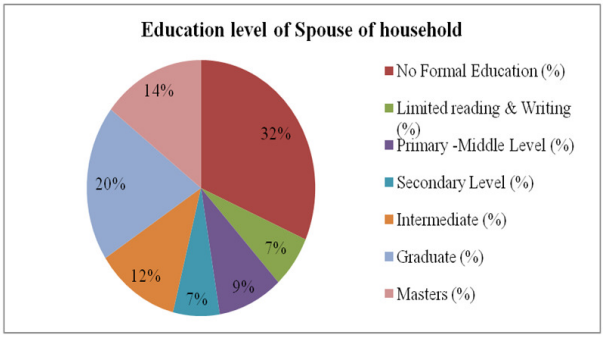

Fig. 6. Education level of Spouses of households (%).

Use of water conservation measures. Almost all households (99%) were familiar with water conservation measures and were willing to adopt water conservation techniques. 58% households consider that water conservation is important due to their religious beliefs, 12% gave weightage to water scarcity, 1% think that water should be conserved as it costs money to extract and supply while; 29% opted multiple reasons out of the aforesaid options.

Existing Water Supply System. Majority of the households (66%) were aware of the actual water supply hours while 34% were not familiar with the municipal water supply hours.

Based on the obtained results from User Perspective Survey it has been concluded that the existing water supply schemes are critically over stressed and are unable to meet the domestic water demand of the targeted houses.

Volume, reliability, and internal water leakages. Most of the households are satisfied with the service delivery issues as 66% were pleased with the volume of water, 79% with supply hours (10 hours per day), 58% were happy about the reliability of municipal water supply. 63% occupants consider that water is enough to fulfill all their domestic water needs. Almost all responded that there are no major water leakages inside their houses.

Terminal Pressure at Domestic Level. The terminal pressure at household level especially in Category A & B Houses is quite low which has resulted in illegal fetching of water by household through reciprocal

pumps installed in 42% of targeted urban houses.58% households said that they have not installed any suction pumps.18% users responded that terminal pressure is enough to fill their overhead water tanks directly, without pumping whereas 82% use pumping arrangements to fill their overhead water tanks for an average duration of 30 minutes per day.

Use of Drinking Water for irrigating recreational Parks. Municipal water is being used uninterruptedly by the Horticulture staff of said township for irrigating the lawns, plants and recreational parks within the residential area which has been leading towards water scarcity in the surveyed houses. Although, municipality has developed few tube wells to irrigate the said parks, but such tube wells are yet not functional.

Use of Municipal Water for Household Activities. Regarding use of municipal water for various household activities, 91% households are using municipal water for drinking purposes. All (100%) use it for bathing, washing utensils and laundry activities. 99% users are utilizing municipal water during cooking. 88% occupants wash their floors using supplied water by municipality, 47% irrigates their plants & lawns whereas 38% wash their cars & motor bikes at home using municipal water. No user mentioned any activity other than above for which municipal water is used by them at domestic level.

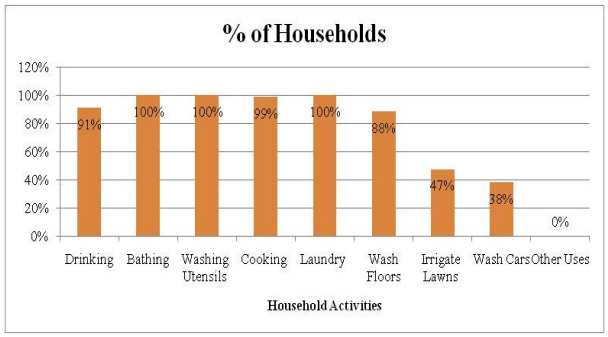

Fig. 7. Uses of Municipal Water at domestic level (%).

Average Duration to use Municipal Water for Household Activities. Households use municipal water for washing utensils in kitchen for an average period of 30 minutes per day. Average duration for using water for laundry is 2 hours per day. It takes approximately an hour per day to wash an average size of 646 Sq Ft washable floors in the targeted houses. The average size of lawns in the targeted houses is 503 Sq Ft which are watered for an average of 24 minutes on daily basis. Households also use municipal water for washing of their cars and motor bikes at home for an average duration of 17 minutes per day.

Capacities of Water Tanks. All (100%) targeted urban houses have overhead water tanks while only 26% were having underground or surface water storage tanks. It means 26% households have got both tanks for water storage. The average capacity of underground water tanks in the surveyed houses is 166 US Gallons while average storage capacity of overhead water tanks was 619 US Gallons.

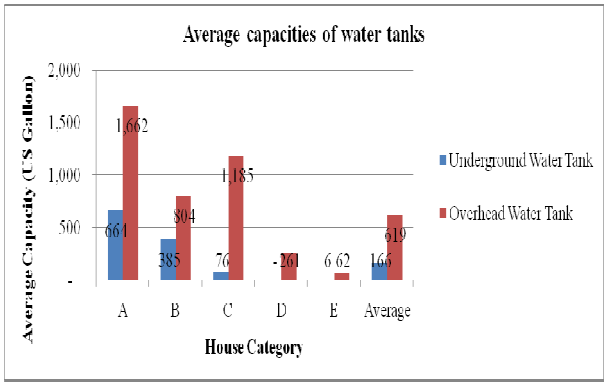

Fig. 8. Average capacities of water tanks (US Gallons).

Quality of Municipal Water.58% households were pleased with the quality of municipal water supplied to their houses while 42% showed some reservations over the quality and reported few common water quality issues being faced by them.

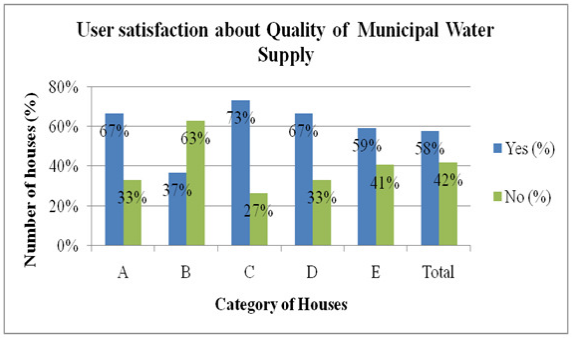

Fig. 9. User satisfaction about quality of municipal water in each category.

Upon further asking about quality related issues, 24% households reported that they have noticed bad taste as well as bad smell, 12% observed grey color, 5% reported blackish as well as radish brown color, 34% occupants mentioned that they have noticed suspended particles in municipal water supply to their houses, 11% observed visible metals while 20% household have noticed any other visible thing in the municipal water supply.

Cleaning of Water Tanks. Households were found reluctant in paying attention towards cleaning of their water tanks as 82% of them reported that they have never cleaned their underground water tanks while 16% households used to clean once in a year. A small number (1%) responded that they clean their underground water tanks half yearly. Moreover, 42% responded that they have not cleaned their overhead water tanks ever while 41% reported yearly cleaning of their overhead water tanks. 12% occupants mentioned that they used to clean their overhead water tanks biannually. Quite few (1%) clean them quarterly while 4% on monthly basis.

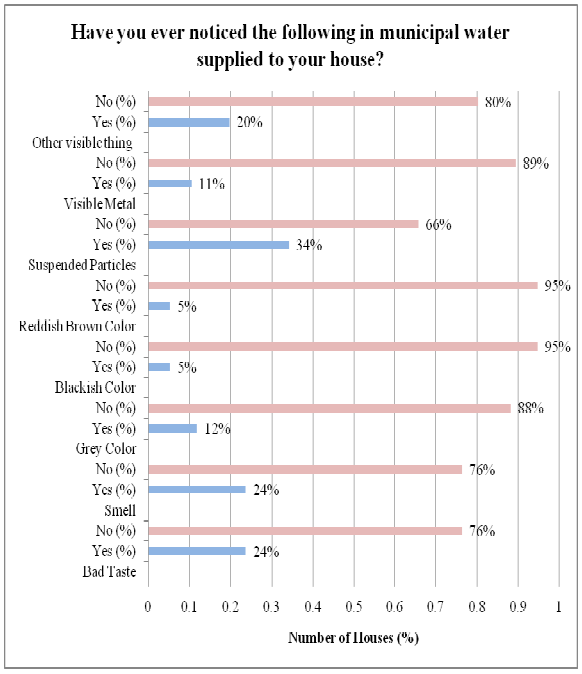

Fig. 10. Water quality issues faced in municipal water.

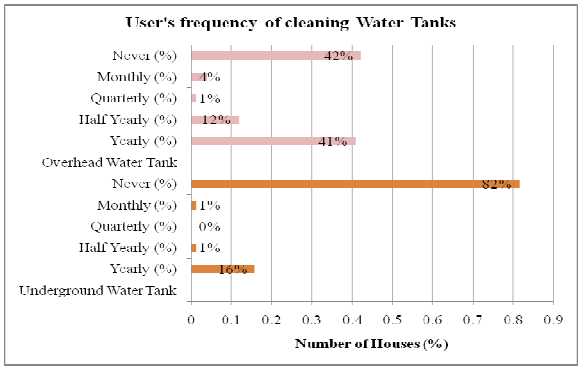

Fig. 11. User's frequency of cleaning underground & overhead water tanks.

Use of municipal water for drinking. 91% of the households in targeted urban houses are using municipal water for drinking while remaining 9% are not using municipal water for drinking purposes.

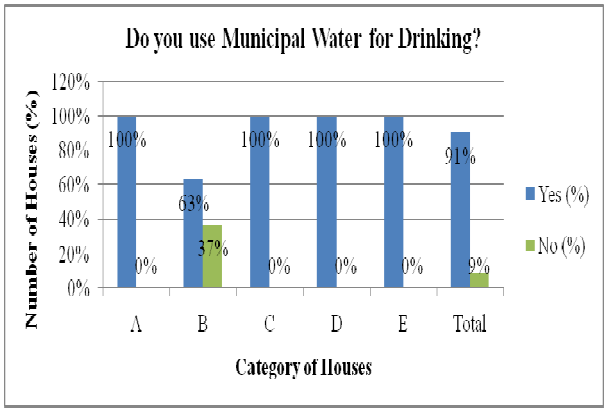

Fig. 12. Household (%) using municipal water for drinking purposes.

Adoption of filtration techniques. While further asking about filtration techniques, 63% households reported that they are drinking tap water directly without boiling, 20% occupants said that they are using supplied water after boiling, 8% household usually drink supplied water after filtration whereas 9% are not using municipal water for drinking purposes.

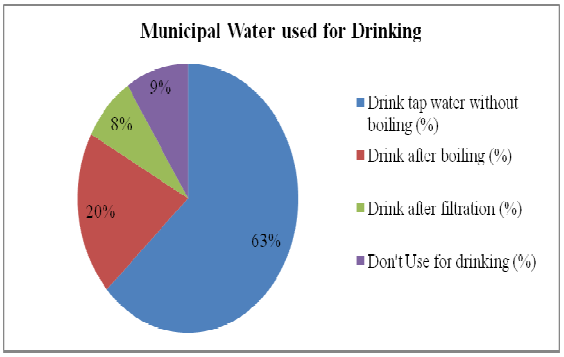

Fig. 13. Users adopting filtration techniques.

Additional Cost incurred on Bottled Water. Household (9%) which are not using municipal water for drinking, have been reportedly utilizing bottled water for the said purpose.

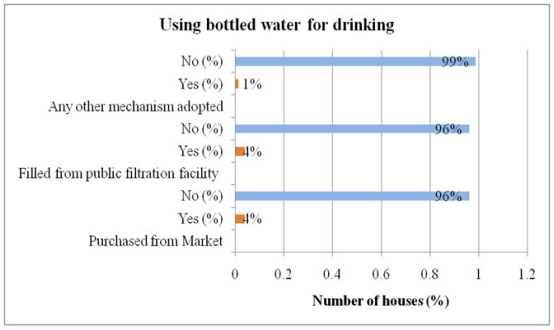

Fig. 14. Household (%) using bottled water for drinking.

Out of which 4% were purchasing bottled water from market whereby incurring an additional average amount of PKR 5,253 (US$32) per month in summer season (April to September) and PKR 3,120 (US$19) per month in winter season (October to March). Remaining 5% occupants have been using bottled water free of cost either filled up from public filtration facilities or using any other free arrangements.

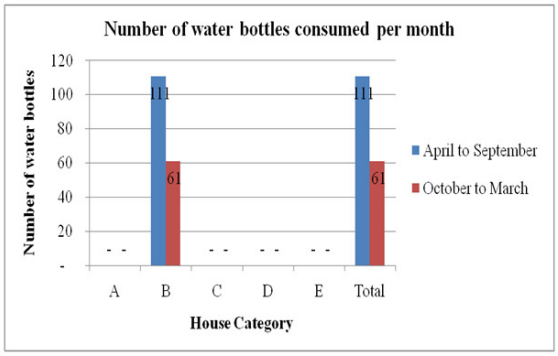

Fig. 15. Number of water bottles consumed per month (both purchased & free).

Total number of water bottles consumed per month by the targeted household in summer season (April to September) is 111 while 61 numbers of water bottles per month are being used by them in winter season.

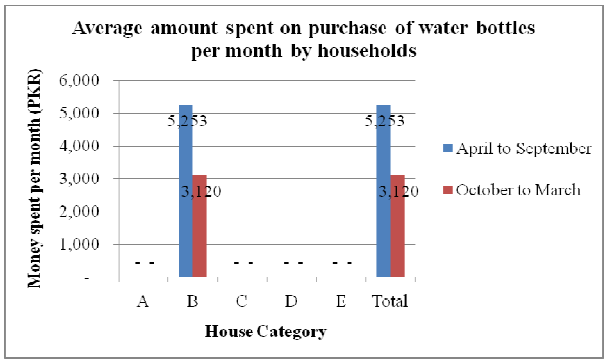

Fig. 16. Average amount spent on purchase of water bottles per month.

Water Pricing. Water bills are being charged by municipality twice a year on fixed slab rate system for each category of the targeted houses on house size basis. Below Fig. 17 gives a synopsis of current water bills being charged by the municipality from each size of housing units after six months.

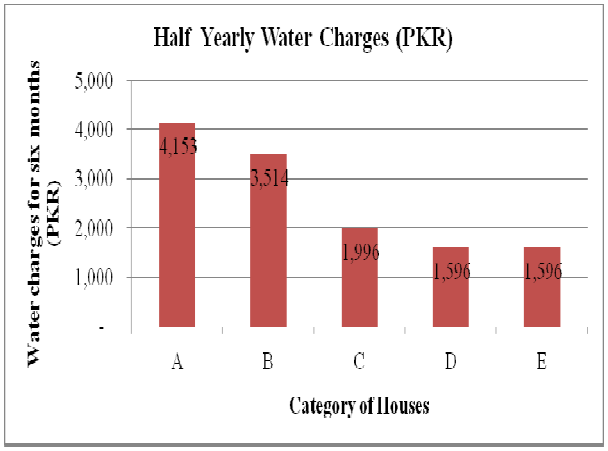

Fig. 17. Half yearly water charges (PKR) for targeted housing units.

Willingness to Pay. 72% residents said that they would like to pay water bill on current rate while 14% households showed their willingness to pay maximum amount up till PKR 1,000 (US$6) per month for water charges if services are improved and water is adequately available. 8% households were ready to pay PKR 2,000 (US$12) per month if water services are improved whereas 4% have been willing to pay maximum up till PKR3,000 (US$18). Even 1% of the household (Category- B who are facing low terminal pressure issue) said that they can pay up to PKR 5,000 (US$30) to PKR 6,000 (US$36) per month to municipality if the water pressure is sufficient to fill their overhead water tank directly.

Willingness to install water meters. 29% households in targeted houses are willing to install water meters while 71% were against the water metering and said that the current slab rate system is suitable for them. Water shortages & Supply thorough Water Tankers.

While reporting about water shortages, 34% household said that they are suffering from water shortages and had ordered supply through water tankers during course of last one year while 66% occupants responded that they had not ordered water tankers in a year. Major reasons of ordering supply through water tankers are water shortages and less terminal pressure. Same was observed in the Category A and B houses who have ordered 60 number of water tankers over the last one year. Although the tanker service is free from municipality, but households had to face a lot of hardships in arranging water tankers.

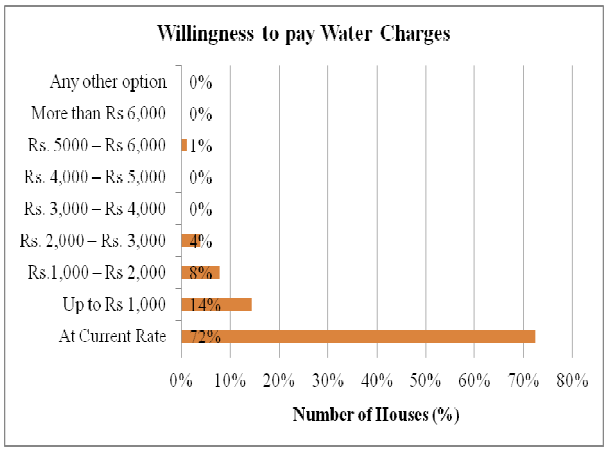

Fig. 18. Willingness to pay water charges by the household.

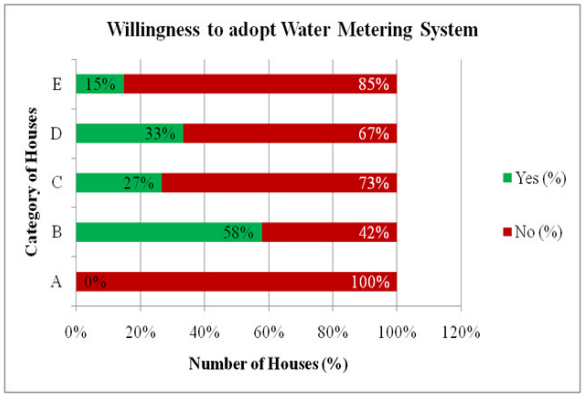

Fig. 19. Willingness to adopt Water Meters.

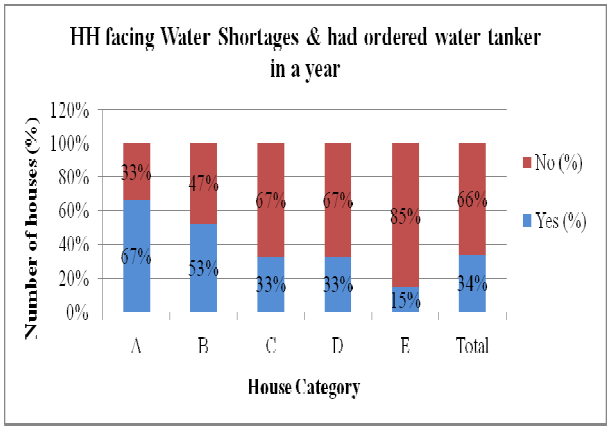

Fig. 20. Household facing water shortages.

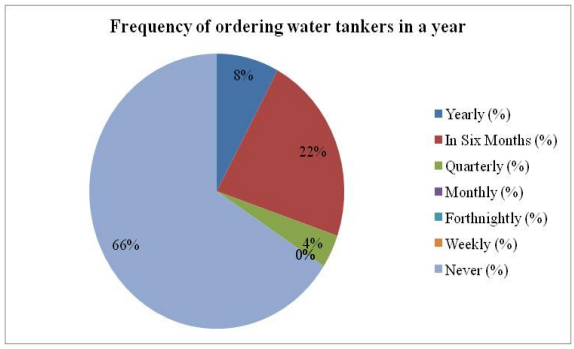

Fig. 21. Household frequency of ordering water tankers in a year.

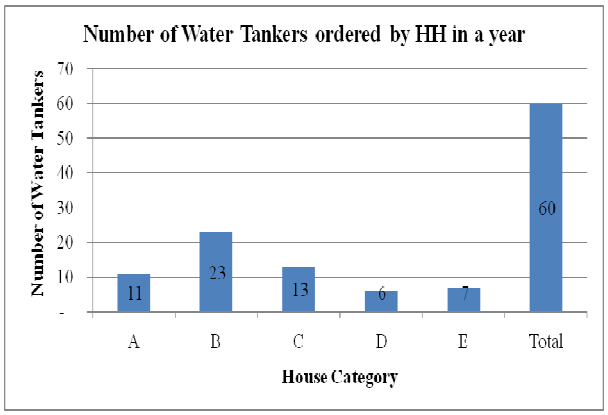

Fig. 22. Number of water tankers ordered in a year.

Frequency of water delivery stoppage. Most of the households (57%) reported that delivery of water gets out of order several times during last one year whereas 43% had never noticed the stoppage of water supply during past one year.

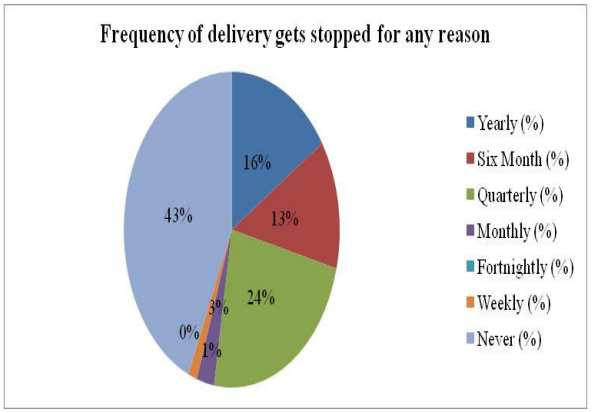

Fig. 23. Frequency of water delivery gets stopped for any reason.

Complaint response and supply restoration time.30% occupants were satisfied with the complaint response time of municipality water staff whereas 36% responded that they are not satisfied with the compliant response time. Remaining 34% had never lodged any compliant regarding water supply services.

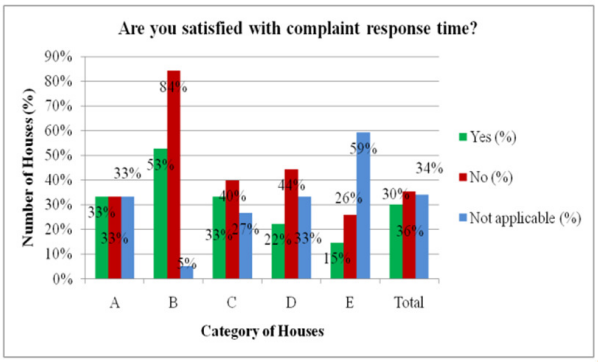

Fig. 24. User satisfaction about complaint response time.

Regarding restoration of water supply, 5% household told that after lodging of complaints supply was typically restored within few hours. 7% occupants said that it was restored after half day, 26% responded that the supply was restored on next day. 11% residents told that it was typically reinstated after two days while 17% said that water supply was restored after three days of lodging their complaint. Remaining 34% had never complained about any discontinuity of water supply.

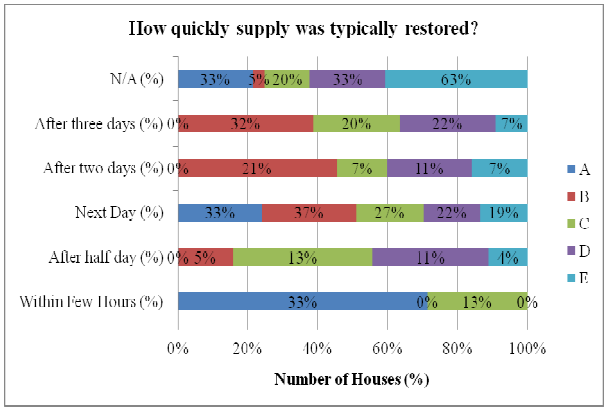

Fig. 25. Level of satisfaction about typical restoration of water supply.

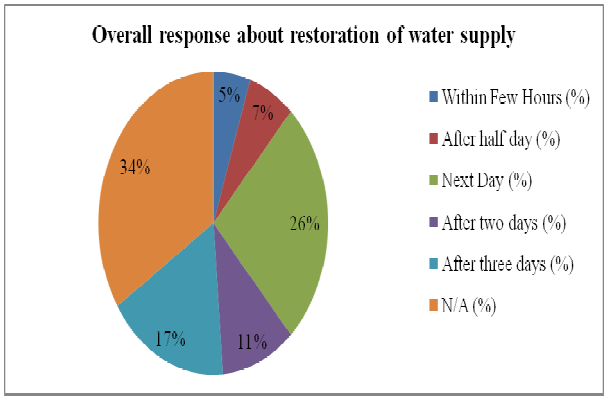

Fig. 26. Overall response about water supply restoration time.

IV. CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations have been derived from the user perspective survey.

Additional water supply schemes should be developed in the targeted area to cater for the domestic water demand and to increase the terminal pressure.

Tube wells already drilled and developed for recreational parks within the residential areas should be made functional so that household gets their due share of municipal water and demand could be met. Moreover, drinking water should not be wasted for irrigating parks and public green belts.

Municipality water staff should run an advocacy campaign in the targeted urban areas for water conservation. Internal as well as external water leakages should be rectified proactively and promptly both by the household as well as water staff of the municipality.

To mitigate the frictional losses as well as leakages due to vegetation and tree roots, municipality should allocate the resources for the replacement of old Galvanized Iron and Asbestos Cement pipelines with larger diameter HDPE pipes as the new housing units are being constructed in the targeted area and the existing schemes are already overcrowded as well as completed their design life.

The results of the study may be shared with the planners and designers to design 24 hours water supply system which would ultimately reduce the chances of contamination in the pipes as water would be available to the consumers 24 hours.

Municipality needs to act proactively upon complaints and should minimize their complaint response time and can improve the service delivery practices based on the user feedback under this research study.

This data can be shared with the provincial government, local government and municipal services department for establishing or designing the future 24/7 water supply schemes for the urban areas of Peshawar.

The utility departments can collect the water charges/revenue from the domestic consumers based on the said real time domestic water consumption results and feedback of the residents.

V. FUTURE SCOPE

The said research work can be a basis for the future studies in urban as well as rural areas regarding condition assessment of existing water supply systems from user perspective. The obtained data would further help to ascertain the needs of additional water sources for the said urban communities. Moreover, said data can be utilized for monitoring the efficiency of on-going water supply schemes in the targeted urban area.

ACKNOWLEDGEMENT

The authors are thankful to National Institute of Urban Infrastructure Planning, University of Engineering and Technology, Peshawar for providing resources required for completing this research work.

Conflict of Interest: This is certified by authors that they have no conflict of interests regarding this study related to financial gains with any other author, researcher, institution, and organization.

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How to cite this article: Aziz, M.I. and Saeed, S. (2021). A Study of Urban Domestic Water Service Delivery through User Perspective Survey. *International Journal of Emerging Technologies*, **12**(2): 01-08.