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Research Paper

Standard Water Pressure: A Leading Parameter of Urban Water Supply System Management

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Abstract *It is a great challenge to the service providers in Urban Local Bodies to render sufficient amount of water with standard quality to the city dwellers. Most of the research works focus on water supply systems in the large cities of the country. Present work is an attempt to find out status of water supply system in small cities. The present research has been carried out based on primary database which has been collected using structured and semi-structured questionnaire survey from the households of Chandernagore Municipal Corporation (CMC) and Hooghly-Chinsurah Municipality (HCM). With the increase of population, demand for water is also getting accelerated in urban area which leads to poor management in water supply system. Standard water pressure with continuity is an important parameter of supply system as it not only controls the amount of water residents are getting but also the quality of water. Therefore, the present research argues about the importance of water pressure in supply system and the external controlling factors of water pressure with spatial variation of pressure condition. In most cases, supply hours and amount of water get the most importance in urban water supply. However, poor pressure condition push back the above indicators into less effectiveness.*

Keywords *Water Supply, Water Pressure, Interzonal Pressure, Intrazonal Pressure, Water Supply Benchmark*

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I. Introduction

Urban water supply is the most crucial basic service among all services. It has become a great challenge in urban water supply system to provide the most important basic service to the citizens following standard norms. In present century, it has got an immense focus in the developing countries. The water supply system is much below than the norms from metropolitan to small cities in India. Ministry of Urban Development, Government of India (2008) has provided guideline to be followed by the Urban Local Bodies (ULBs) for water supply. However, most of the cities are supplied much less than the standard services of water supply in India. The guideline has mentioned nine indicators for water supply including sufficient water pressure as sub-indicator of one of the above. Standard water pressure with continuity is an important parameter of supply system as it not only controls the amount of water residents are getting but also the quality of water. Therefore, the present research argues about the importance of water pressure in supply system and the external controlling factors of water pressure with spatial variation of pressure condition.

The present research work has been carried out in two class-I cities of West Bengal; these are Chandernagore Municipal Corporation (CMC) and Hooghly-Chinsurah Municipality (HCM). CMC and HCM are two adjacent cities of West Bengal. They are situated on the Eastern most part of Hooghly district. CMC and HCM are surrounded by Bansberia Municipality in the North, Bhadreshwar Municipality in the South, river Ganga to the East and different rural *mouzas* in the West. The area is located between two rivers, the Ganga to the Eastern part and the Saraswati to the Western part. The geographical location of the study area is 22^{o}50′54″ N to 22^{o}57′17″ N and 88^{o}18′24″ E to 88^{o} 24′ 26″ E (Fig. 1)**.** There are 33 wards in CMC and 30 wards in HCM. Ward number 27 is out of the present research work as it is located isolated in between Bhadreswar municipality and Champdani municipality and water is supplied to this particular ward by the adjacent municipalities as per the contract with CMC. The geographical area occupied by CMC and HCM is 22.03 sq. km and 17.27 sq. km respectively. The year of establishment of CMC is 1955 and of HCM is 1865 [1]. The population size of CMC and of HCM is 1, 66,949 and 1, 77,209 as per the Census of India, 2011 [2]. There are

152 slums in CMC with a population of 27 per cent of the total [3]. There are 140 slums in HCM with a population of 32 per cent of the total population [4].

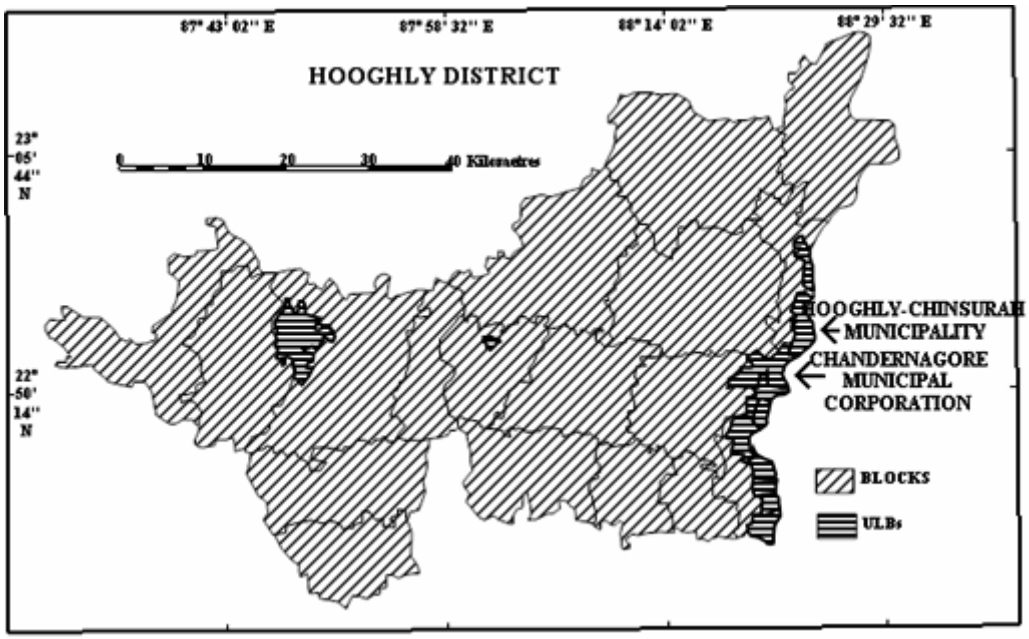

Fig. 1. Location Map

II. Materials & Methods

The present research has been carried out based on primary database which has been collected using structured and semi-structured questionnaire survey from the households in 2012. Water supply information from city residents has been collected from four zones of both cities. The zones demarcated are based on the geographical position of the wards and their population density. The number of sample has been selected from each zone of both the cities at the rate of 0.5 per cent of the total households (2001) of the concerned zones. The samples have been selected following stratified random sampling. The stratification is made by non-slum and slum areas from each zone. Here, the total number of sample is 178 for CMC and 190 for HCM. Water pressure has been measured from each and every sample households using a container having capacity of 10 litres. The pressure has been measured in such a way that how much time it takes to fill the above mentioned container.

Water Supply in CMC & HCM

Water supply is the one of prime basic services provided by the authority of a city. The main challenge of Indian cities is to provide an equitable water supply [5]. Many scholars from different parts of the country are working on sustainable and efficient water supply in urban areas of the country. The average water supply in the class-I cities in India is 191.05 litres per capita per day (lpcd) and in West Bengal is 187.88 lpcd [6]. CMC and HCM though fulfill the standard norm (135 lpcd), but much less than the country and state's averages [7]. The source of water supply is both ground water and surface water in CMC; however, the most dependency goes to ground water. In the newly added area (Western zone) of CMC the infrastructure of water supply is poor and this is under construction to reduce the difference from old area (Northern, Central and Southern zones). The source of water in HCM is ground water mainly. Water is supplied to the city by the authorities either by household connection or by road-side tap. There is no metering system of household connection in HCM; however, a few households are connected with metering system in CMC (Table. 1). Desai (2013) has commented that water supply through metering system should be compulsory [8].

Table 1. Water Supply as a Basic Service in CMC and HCM

Attributes	Benchmarks	Non-slum areas		Slum areas	
		CMC	HCM	CMC	HCM
Water supply connection (%)	100	84.1	90.4	58.0	53.2
Per capita water supply (lpcd)	135	135	135	135	135
Metering of water connections (%)	100	7.0	Nil	0.0	Nil
Water supply hours/ day	24	12.5 (old area, CMC), 13 (HCM) 9 (added area, CMC)		12.5 (old area, CMC), 13 (HCM) 9 (added area, CMC)	

Source: Field survey, 2012

Water Pressure Condition

Traditionally, water pressure is defined as the amount of water discharged through a tap by the ULBs. Water pressure is more important indicator at the household level services of water supply rather than supply hours. Supply hours are shorter when the pressure is very poor and also poor pressure condition is an obstacle to get sufficient amount of water. Low water pressure is one of the major issues of urban water supply in India [9]. Low water pressure not only provides less amount of water simultaneously it deteriorates quality of water also [10]. For the field survey a container (having a capacity of 10 litres) has been used and it was noted that how much time it takes to fill the aforesaid container. This pressure is called as 'measured pressure' by Zerah (2000) [11]. This measured pressure has been observed from 368 households of selected four zones of CMC and of HCM. These zones are Northern, Central, Western and Southern for CMC and Northern, Eastern, Central and Southern for HCM. Slum and non-slum both types of households have been chosen from the four zones. These zones have been selected according to their population density and their geographical locations.

Water pressure varies over the area drastically. This variation is not only spatial but also seasonal. The water pressure also differs over times in a day. This pressure condition has become worse than before because of augmentation of household connections from a pipe line. In summer season this problem gets more prominent. Comparative analysis of water pressure in a day depicts that water pressure is good in the early morning and late afternoon as minimum numbers of taps are open during that time. The rest of the day belongs to the moderate to the poor pressure condition. A few places are also there where the pressure condition is the worst and sometimes they have to dependent on road-side tap to collect water irrespective of having their own household connections. The pressure condition (PC) is dependent on many external factors such as, distance from the pump house (Pd), connection to the main pipe (Pmc), elevation of land (Le), position of tap (Tp), clearance of pipe (Cp). From the field observation, the pressure condition can be expressed as:

$$PC = f(Pd, Pmc, Le, Tp, Cp)$$

Therefore, the pressure condition is good in the households who are located near the pump houses, connected directly to the main pipe, located at low elevation and also to the households whose tap is fixed at a lower position. With the increase of height of the tap pressure gets reduced. To overcome the problem most of the households having multi-floors store the municipal supplied water in a reservoir at the ground and pump it to their reservoir at the top of the building. These extra infrastructural design leads to higher cost (capital and maintenance cost of the self-employed tanks) to the households which is the direct outcome of the inefficient governance of the cities. However, poor people have to accustom with the low pressure water supply as they cannot afford the above mentioned cost for better supply design. This fact expresses that inefficiency in water governance generates a gap between rich and poor people in the cities to get water supply service. As the number of open taps is minimum in the early morning and late afternoon, households get better pressure condition in that time than in the rest of the day. It is observed in few places that the worst pressure condition has shortened the duration of supply hours. The inadequate pressure condition has compelled the households to adjust their demand with the amount of water they get.

The mean measured water pressure in the non-slum areas of CMC is maximum in Western zone (1.12 minutes/ 10 litres) and the minimum is found in Central zone (2.39 minutes/ 10 litres) (Table. 2; Fig. 2). However, the maximum pressure has been observed in slum areas of CMC in Northern zone (0.71 minutes/ 10 litres) and minimum in Central zone (1.74/ 10 litres) (Table. 2; Fig. 3). From the above, it is clear that the non-slum and slum response same in the Central zone where water pressure is the worst in comparison to other zones (Fig. 4).

Table 2. Measured Water Pressure of Non-slum and Slum Areas of CMC Having Household Connection (Minutes / 10 litres)

Zones	Mean for non-slum	Mean for slum	Standard deviation for non-slum	Standard deviation for slum	CV for non-slum (%)	CV for slum (%)
Northern	1.51	0.71	0.5	0.31	33.11	43.66
Central	2.39	1.74	1.02	0.36	42.47	20.68
Southern	1.86	1.42	0.71	0.52	38.17	36.61
Western	1.12	0.98	0.78	0.58	69.64	59.18

Source: Computed by author based on field survey, 2012

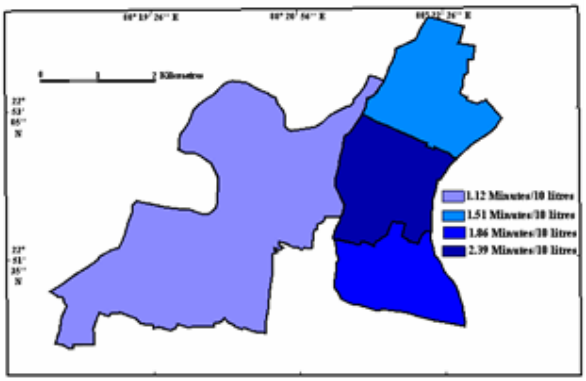

Fig. 2. Mean Measured Water Pressure of Non-slum Areas with Household Connection in CMC

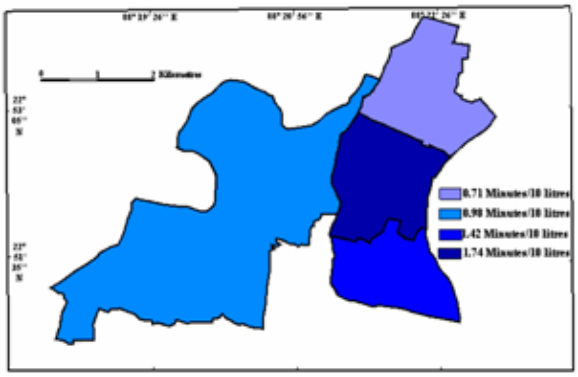

Fig. 3. Mean Measured Water Pressure of Slum Areas with Household Connection in CMC

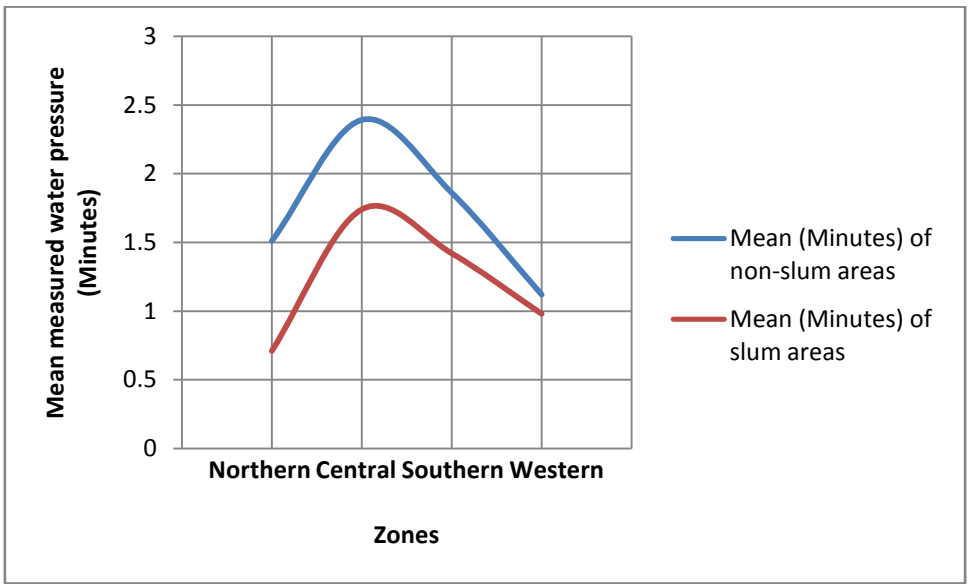

Fig. 4. Comparative Analysis of Water Pressure in Non-Slum & Slum Areas of CMC

The range of water pressure shows that the water pressure condition is far better in slum areas of CMC than non-slum areas in the households having water connection. There is also prominent variation in the zonal variability of mean measured water pressure. The maximum variability has been observed in Western zone (69.64%) in the non-slum areas of CMC and minimum in Northern zone (33.11%)(Table. 2; Fig. 5). However, the maximum and minimum variability is found in Western zone (59.18%) and in Central zone (20.68%) respectively in the slum areas of CMC (Table. 2; Fig. 6).

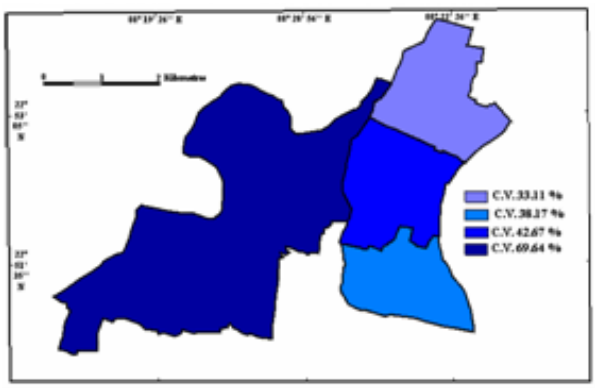

Fig. 5. Co-efficient of Variation of Measured Water Pressure of Non-slum Areas with Household Connection in CMC

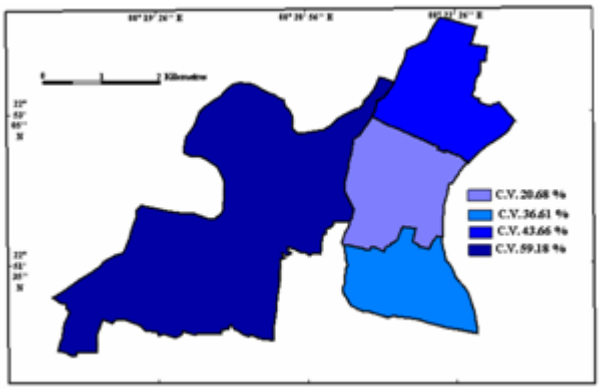

Fig. 6. Co-efficient of Variation of Measured Water Pressure of Slum Areas with Household Connection in CMC

The mean measured water pressure in the non-slum areas of HCM having household connection is minimum in the Central zone (3.16 minutes/ 10 litres) and maximum in Eastern zone (1.88 minutes/ 10 litres) (Table. 3; Fig. 7). The mean measured water pressure in the slum areas having household connection is minimum in Northern zone (2.89 minutes/ 10 litres) and maximum in Central region (1.67 minutes/ 10 litres) (Table. 3; Fig. 8). The variability in the mean measured water pressure is maximum in Northern zone (CV 67.42%) and minimum in Southern zone (CV 54.81%) in non-slum areas of HCM (Table. 3; Fig. 9). However, the variability is the highest in Southern zone (CV 67.68%) and the lowest in Eastern zone (CV 28.47%) in slum areas of HCM (Table. 3; Fig. 10). Figure 11 shows that the zonal water pressure condition is almost reverse in non-slum and slum areas of HCM.

Table 3. Measured Water Pressure of Non-slum and Slum Areas of HCM Having Household Connection (Minutes / 10 litres)

Zones	Mean of non-slum	Mean of slum	Standard deviation of non-slum	Standard deviation of slum	CV of non-slum (%)	CV of slum (%)
Northern	2.64	2.89	1.78	1.80	67.42	62.28
Eastern	1.88	2.74	1.14	0.78	60.64	28.47
Central	3.16	1.67	2.07	0.56	65.51	33.53
Southern	2.39	2.63	1.31	1.78	54.81	67.68

Source: Computed by author based on field survey, 2012

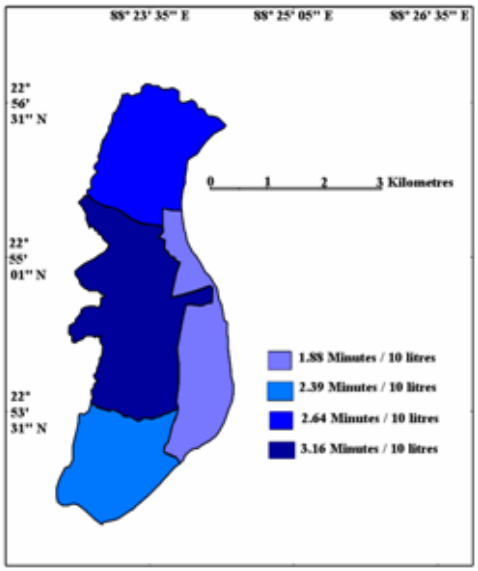

Fig. 7. Mean Measured Water Pressure of Non-slum Areas with Household Connection in HCM

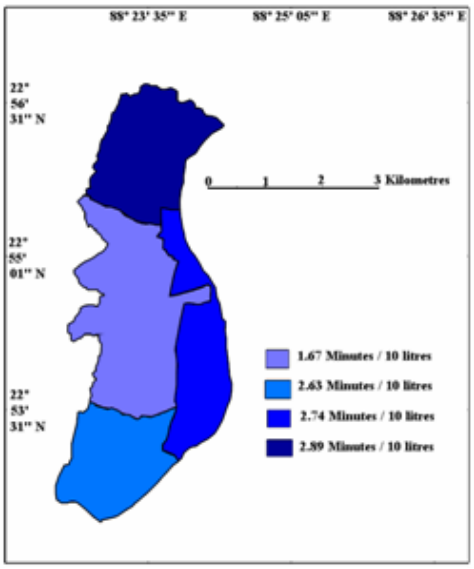

Fig. 8. Mean Measured Water Pressure of Slum Areas with Household Connection in HCM

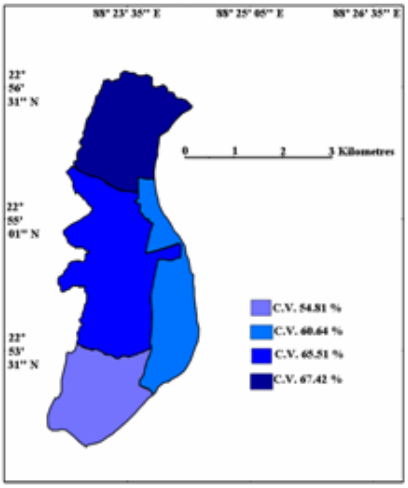

Fig. 9. Co-efficient of Variation of Non-slum Areas with Household Connection in HCM

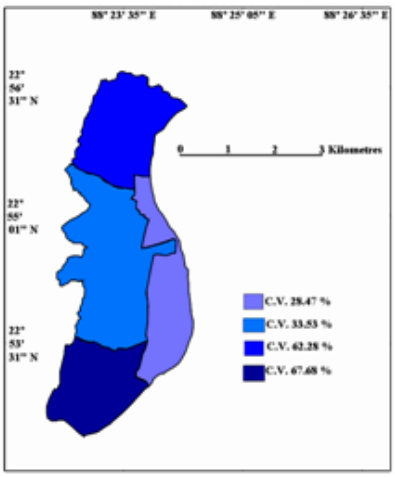

Fig. 10. Co-efficient of Variation of Slum Areas with Household Connection in HCM

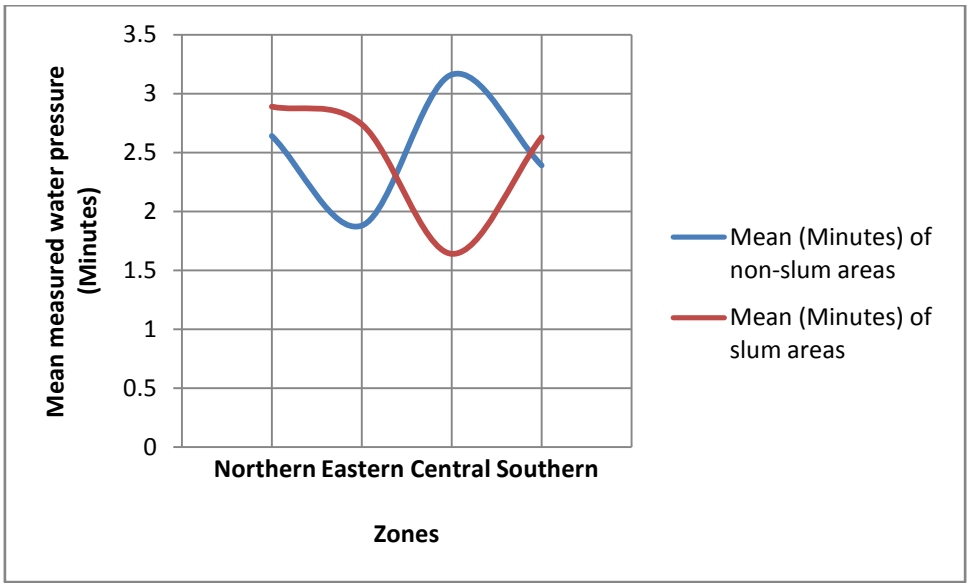

Fig. 11. Comparative Analysis of Water Pressure in Non-Slum & Slum Ares of HCM

Interzonal & Intrazonal Pressure Condition

It is already mentioned that the pressure condition differs over the zones in both cities. There is also variation in water pressure in a specific zone. For the analysis of interzonal pressure condition the range of water pressure from non-slum and slum areas has been divided into three classes. On the basis of these classes, all the zones either non-slum or slum has been analyzed. Intrazonal condition of water pressure has been analyzed based on the data range of a particular zone separating non-slum and slum areas. Interzonal analysis gives a detail zonal account of a city based on a fixed reference line of discussion, whereas the intrazonal account depicts the comparison within a particular zone.

CMC area has been classified into three water pressure condition for the interzonal analysis. These are good (<1.81 minutes/10 litres), moderate (1.81-3.2 minutes/10 litres) and poor (>3.2 minutes/10 litres). Non-slum areas of CMC shows that pressure condition is much consistent in Northern and Western zone as they belong to good and moderate pressure condition (Fig. 12). Most of the households belong to good pressure condition in Central zone. Number of households belonging to poor pressure condition is higher in Central zone than Southern zone (Fig. 13). The maximum range of water pressure has been observed in Central zone and minimum in Northern zone of non-slum areas. Interzonal pressure condition of slum areas of CMC shows better condition than of the non-slum areas of CMC. In slum areas all the households of different zones belong to good pressure condition (<1.81 minutes/10 litres) except Central zone. Therefore, pressure condition of the Central zone is worse in slum and also in non-slum areas of CMC than other zones. From the overall scenario of water pressure of CMC, it is clear that slum areas respond better than non-slum areas in terms of interzonal pressure condition. Intrazonal pressure condition in non-slum areas of CMC shows that the Central zone belongs to the most extreme as the households either belong to good pressure condition or poor condition; here is no category of moderate condition (Fig. 14). In slum areas, the extremity is observed in Southern and Western zone of CMC in terms of intrazonal pressure condition (Fig. 15).

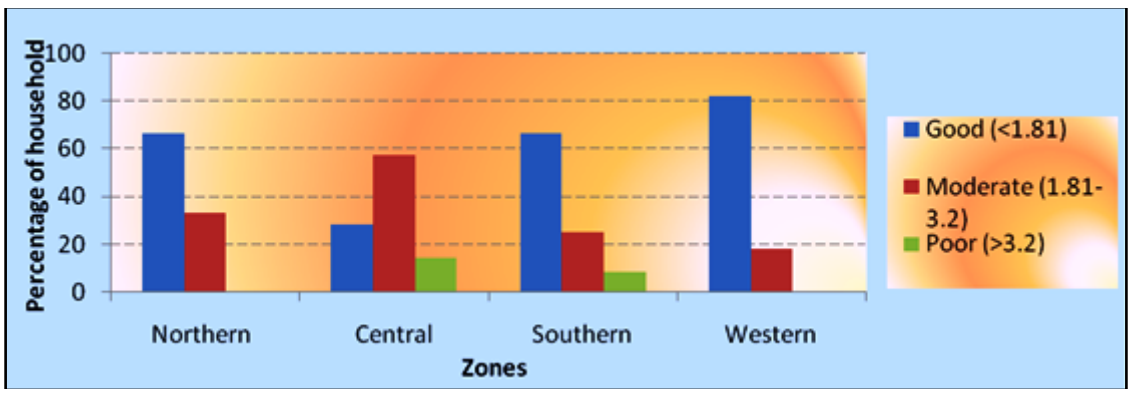

Fig. 12. Interzonal Pressure Condition in Non-slum Areas of CMC (minutes/10 litres)

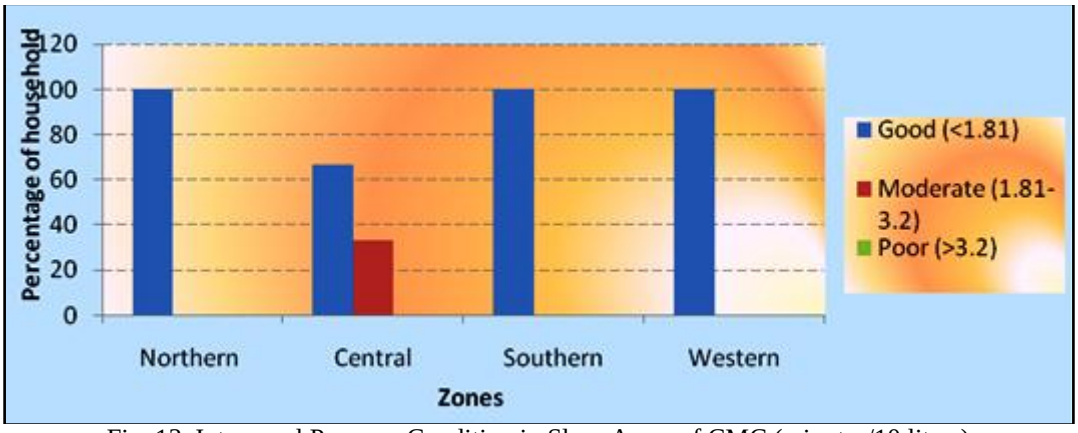

Fig. 13. Interzonal Pressure Condition in Slum Areas of CMC (minutes/10 litres)

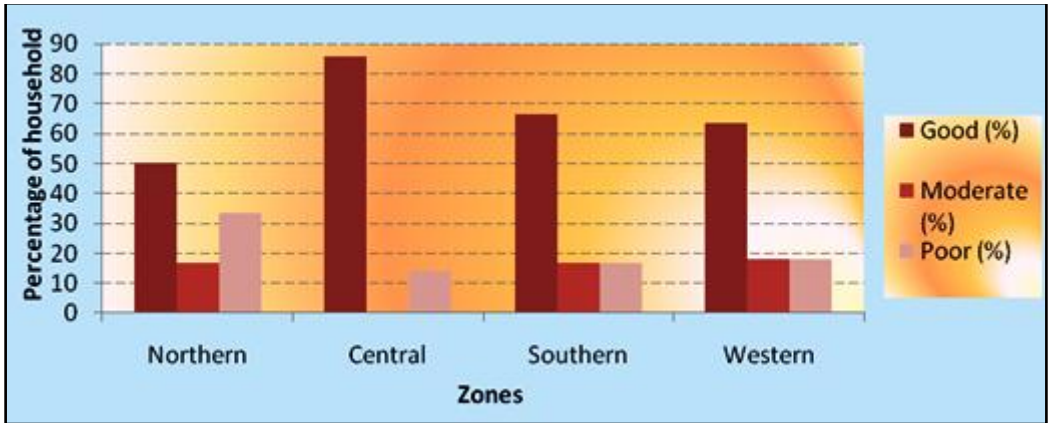

Fig. 14. Intrazonal Pressure Condition in Non-slum Areas of CMC (minutes/litres)

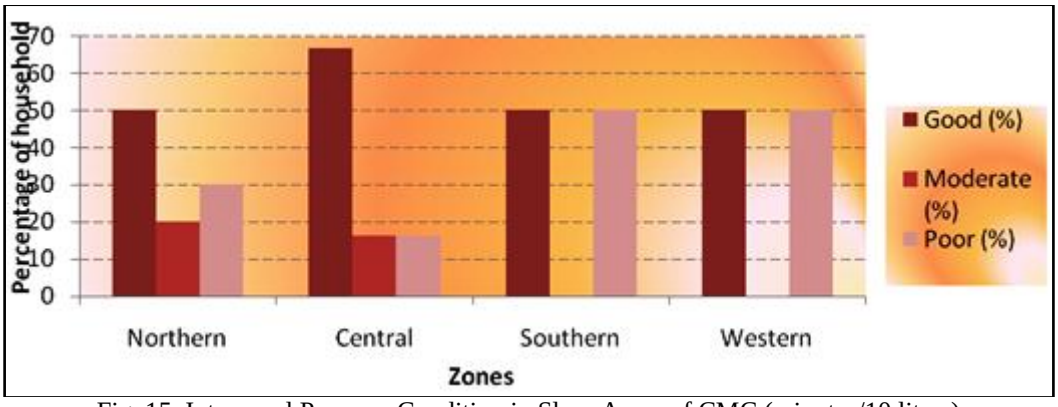

Fig. 15. Intrazonal Pressure Condition in Slum Areas of CMC (minutes/10 litres)

HCM is classified into three pressure condition for the analysis of interzonal pressure condition, these are good (<3.25 minutes/10 litres), moderate (3.25-5.80 minutes/10 litres), and poor (>5.80 minutes/10 litres). Most of the households belong to good pressure condition in the Eastern zone of non-slum areas and other zones respond the same in terms of households belonging to the good pressure condition (Fig. 16). Overall picture of pressure condition in non-slum areas of HCM shows that Southern and Eastern zone are better than Northern and Central zone. All the households of Central zone in slum areas belong to good pressure condition. Southern zone is worse in comparison to the other zones of slum areas of HCM (Fig. 17). Therefore, non-slum and slum area do not respond maintaining a pattern of interzonal pressure condition, rather it is irregular. From the intrazonal water pressure condition it comes out that there is a similarity in the pattern except Central zone of non-slum areas of HCM (Fig. 18). However, there is an irregularity in the pattern of intrazonal pressure condition of slum areas of HCM (Fig. 19). In slum areas, Northern zone responds the best condition and Eastern zone responds the worst condition in intrazonal pressure condition.

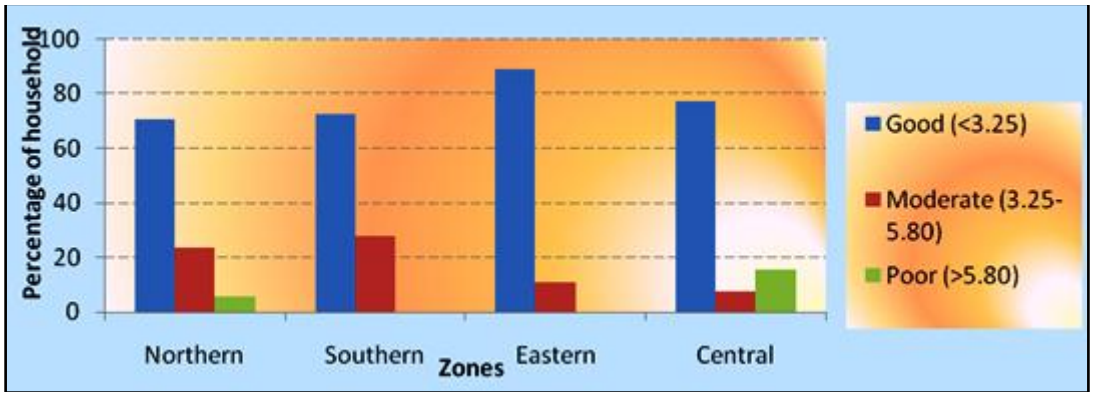

Fig. 16. Interzonal Pressure Condition in Non-slum Areas of HCM (minutes/10 litres)

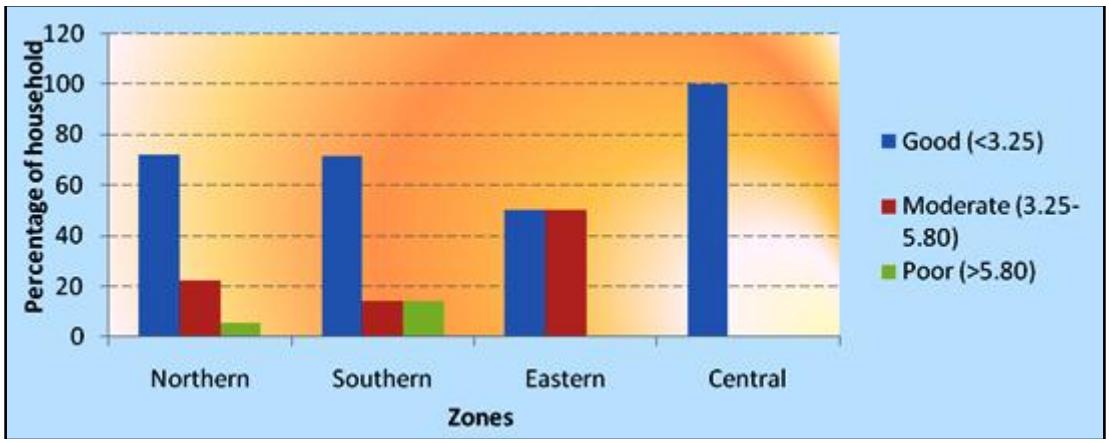

Fig. 17. Interzonal Pressure Condition in Slum Areas of HCM (minutes/10 litres)

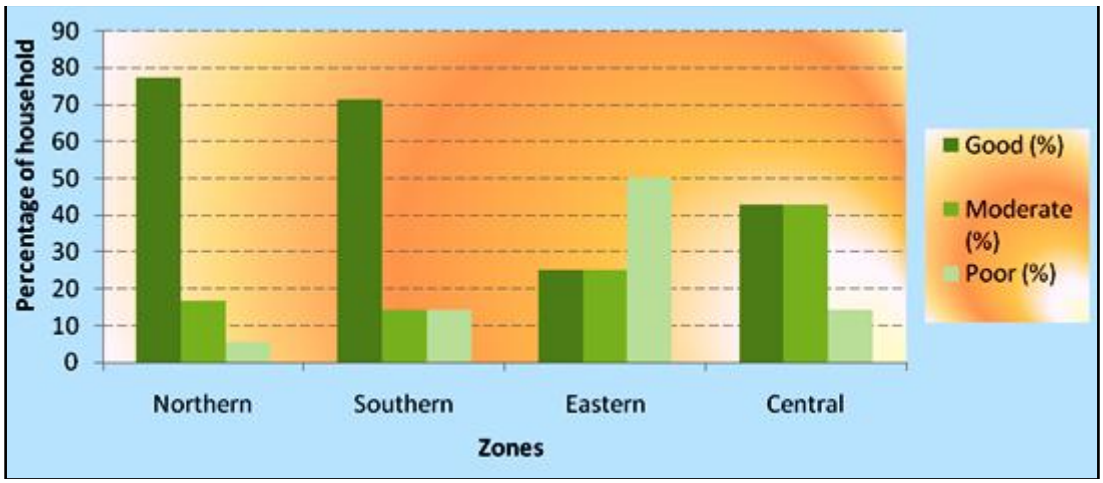

Fig. 18. Intrazonal Pressure Condition in Slum Areas of HCM (minutes/10 litres)

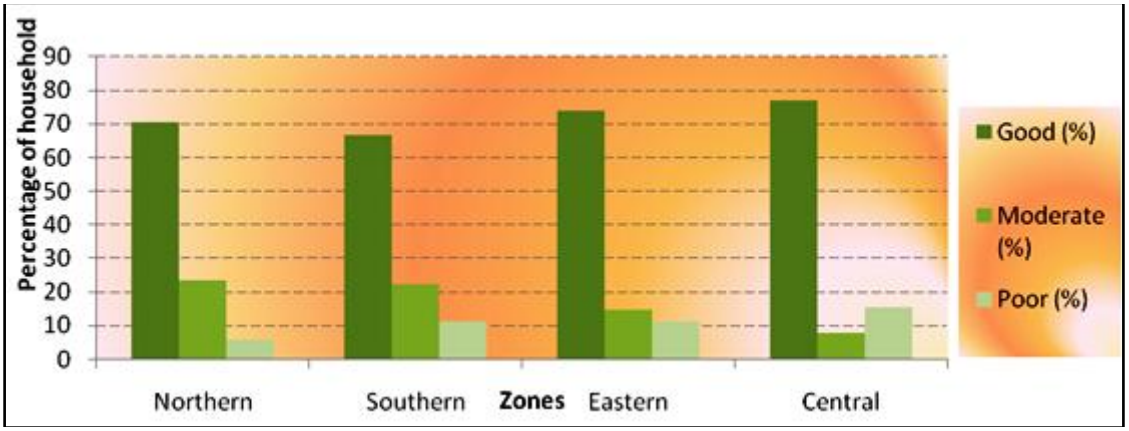

Fig. 19. Intrazonal Pressure Condition in Non-slum Areas of HCM (minutes/10 litres)

III. Conclusion

Water pressure condition, a least prioritized mater to the authorities of ULBs can hinder water supply system. In most cases, supply hours and amount of water get the most importance in urban water supply. However, poor pressure condition push back the above indicators into less effectiveness. Poor pressure condition leads to shorten supply hours and also it results into less amount of water. It has also been observed that the households having low water pressure are accustomed with less amount of water. Sometimes they have to collect water from nearby stand posts to overcome the scarce situation. Therefore, water pressure condition should be given parallel importance like other indicators by the authorities from national to city level for efficient water governance.

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