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Eliminating the Dependency on Groundwater by Switching from Intermittent Water Supply to Continuous Water Supply in Pan City Chandigarh - A Case Study

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Abstract

In the early 50's when the city of Chandigarh was developed, the population of the city was sparse and the yield of tube wells was sufficient to meet the water supply demand of the city. As such, the town's water supply was based on groundwater sources. With time, the population manifolds of the city have increased considerably. The usage of surface water was added later in the year 1983 but the water table in Chandigarh city has been found depleting like many states of India. In this scenario, if the city of Chandigarh having one million population is provided with a continuous water supply this might appear that the addition of a continuous water supply will worsen the water balance, but the situation is different from the hypothetical hypothesis. On the contrary, the introduction of continuous water supply using surface water alone could result not only in the saving of groundwater levels for the coming years but also in the overall consumption of water. Society as a whole would benefit from the project from a reduction in water-borne diseases, emission level reduction of GreenHouse Gases and lesser stress of storing water. The case study presents data from water tables collected from authentic sources, ground visits, and a comparison of generation and usage of groundwater sources. The case study is an attempt to detail the methods to reduce dependencies on groundwater and adopt a continuous water supply scheme while strictly maintaining the norms set by regulatory agencies of India (CPHEEO) i.e. 150 Liters per Capita per Day (LPCD).

Keywords
CPHEEO, LPCD, Ground Water, Surface water source, 24X7 availability, and Aquifer System

1. Background
The city of Chandigarh is located on the western side of the Shimla National Highway and river Gaggar. The Union Territory of Chandigarh is located in the foothills of the Shivalik hill ranges in the north, which forms a part of the fragile Himalayan ecosystem. The average annual rainfall is 1059 mm. The city also receives occasional winter rains from the western disturbance over the Mediterranean Sea. Under the city's water bylaws, every planned dwelling unit has to have water and sewerage connections. With the formation of U.T. in 1966, all the works for the city's physical infrastructure development were handled by the respective departments of the Chandigarh Administration. The Municipal Corporation of Chandigarh was created in 1994 and the city's water supply, sewerage system, stormwater

drainage, solid waste management & sanitation have been transferred to the Municipal Corporation since then. **(**Sanjeev Chauhan et al. 2022**)** There are two types of sources which could be tapped for the city water supply: -

1. Surface water source
2. Groundwater source

1.1 History of groundwater and surface water data

In the early 1950's the population of the city was sparse and the yield of tube wells was sufficient to meet the city's water supply demand. As such, the water supply of the town was based on tube well source alone. Moreover, no surface water source was available in the vicinity of the town. Over the passage of time, the population of the city has increased considerably due to the influx of population from other states resulting in substantial pressure on the city's water supply system. Due to the continuous tapping of underground sources, the water table in the area started depleting. As such, it was not possible to depend on the underground water source alone for the entire water requirement of the town in the future. The idea of constructing a dam on the Ghaggar River to tap the surface water source was also contemplated in the early sixties, but this project could not make any headway due to the bifurcation of Punjab and Haryana. **(**Jha B.M. 2007**)**

2.Aquifer systems in Chandigarh

Chandigarh area can be divided into two zones for the aquifer management plan i.e. Zone A and Zone B.
Zone A covers sectors 39, 55, 54, 53, 52, 43, 44, 42 & 40 where water logging is observed therefore, it is suggested that shallow aquifer water be extracted for secondary uses and artificial recharge should not be attempted in this zone. Zone B covers the rest of Chandigarh where the water level is declining and recharges of a deeper aquifer with a depth slot between 70-90 mbgl (meters below ground level) should be done. (Rathore M.S.2003)

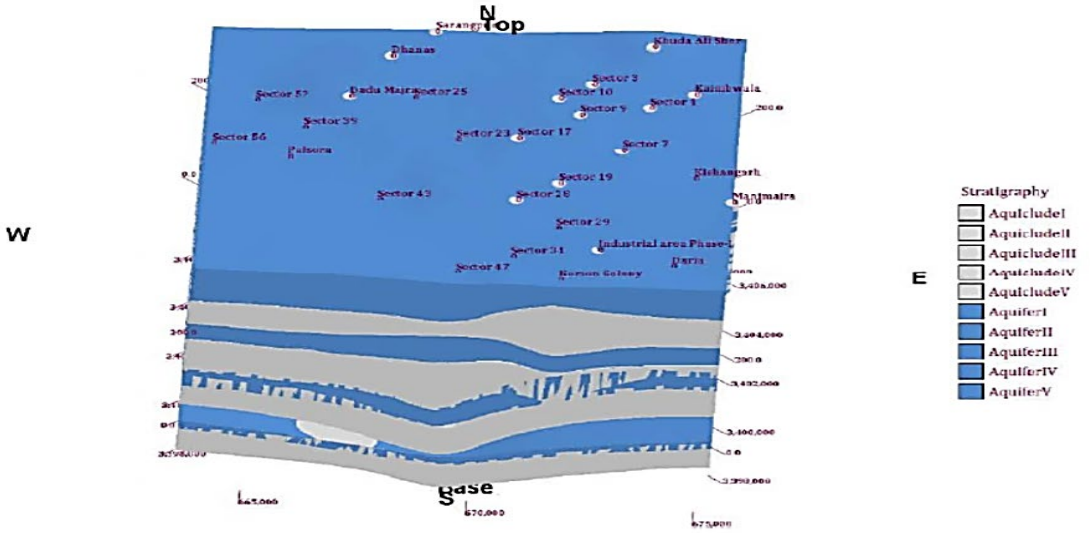

Figure 1. Dimension Aquifer Model - Chandigarh (U.T.)

The aquifer in Chandigarh is mainly composed of fine to coarse-grained sand. Towards the northern and northeast parts of the city, the aquifer is found to be thicker as compared to other areas of the city. In addition, the number of aquifer zones is lower in the west and south-western parts of the city than in the northeastern and northern parts. (Singh D.K. et al. 2002**).**

2.1 Comparison of Groundwater Status of Chandigarh UT

If the water tables are o**bser**ved from 2013, we shall find that the water table in Chandigarh city is depleting steeply. This is also deteriorating the groundwater quality.

Table 1. Comparison of Groundwater Status of Chandigarh UT

	2013	**2017**	**2020**
Annual Extractable Groundwater Resource (Ham i.e. Hectare Metre)	1943	3794	5738.04
Gross Groundwater Draft (Ham)	NIL	3378	4624.70
Net GW Availability for Future Irrigation Development (Ham)	1943	416	1113.34
Over Draft	Nil	Nil	Nil
Stage of Ground water development in %	0 %	89%	81%
Category	**SAFE**	**SEMI CRITICAL**	**SEMI CRITICAL**

In a span of 10 years, the groundwater table category for Chandigarh has degraded from safe to semi-critical. The major reason is the increase in the amount of annual extractable groundwater resource from 1943 ham (hectare meter) in 2013 to 5738.04 ham by 2020. Also, there is no draft from shallow aquifers, however, the groundwater is being abstracted from deeper aquifers to the tune of 4624.70 ham/ year which makes Chandigarh UT fall under the semi-critical category. **(**Alegre et al. 2006)

2.2 Motivation and need of the project

From Table 1, it is concluded that the stage of groundwater development goes from 89% to 81%. Although there is a decline of 7% yet 5738.04 ham was observed as the annual extractable groundwater resource in 2020. If the extraction is continued in the same manner, the groundwater level shall reach quite minimum and dangerous levels within a decade. It is essential to start preserving groundwater from today itself so as to keep the future groundwater table intact. It might appear that the addition of a continuous water supply will worsen the water balance, but the situation is different from the hypothetical study. On the contrary, the introduction of continuous water supply using surface water alone could result not only in the increase of groundwater levels for the coming years but also in a higher overall consumption of water. The society as a whole would benefit from the project.

2.3 Objectives

To introduce continuous water supply using surface water alone to meet the target of 150 LPCD as per CPHEEO norms.
To reduce the non-revenue water losses from 35% to 15%
To keep the deep aquifers safe by using only shallow aquifers when required.

To stop the further use of groundwater through tube wells to a minimum or no use.

3.Benefits of 24/7 water supply

Cities that implement continuous 24x7 water supply have found that their water consumption per capita is reduced in the long run. Introducing continuous water supply will also have a greater impact on depleting groundwater and stressed aquifers. The reduction in the depletion of water will improve the sustainability of groundwater. Society as a whole would benefit from the project, whereas meeting the target of 150 LPCD using only surface water will put a halt to further exploitation of groundwater sources. (Dahasahasra D.S. et al. 2010)

3.1 How 24/7 continuous supply can reduce the dependency on groundwater

Chandigarh city has a distribution of 227 LPCD (litres per capita per day) which is much above the prescribed limit by CPHEEO (Central Public Health & Environmental Engineering Organisation) norms i.e. 150 LPCD. The collected data states that a continuous water supply is possible to achieve while targeting the CPHEEO norms by simply relying on the surface water source available and not adding any new water resource. However, the city distribution supply is intermittent and also suffers from leakages and water contamination problems due to old PSC (Prestressed concrete type) and ACP (Asbestos cement pipe) pipelines. Also, the metering policy is absent at the consumer end. The losses as detected amount to nearly 35% of the total water supplied. Data collected from the water works department of the municipal corporation Chandigarh reveal that the city losses are up to 35 per cent due to underground leakages and other reasons. This is 20 per cent higher than the national average of 15 per cent. **(**Seiji Kojima et al., 2005)

4. Methodology to reduce NRW (Non-Revenue Water) and attain continuous water supply using surface water alone

Hydraulic Modeling

It is a major activity to be carried out so as to judge the suitability of the existing network for supply progressive demand, replacement /rehabilitation required in phases to meet the requirement.

Integration of DMA with SCADA

The necessary integration of SCADA (supervisory control and data acquisition) is one of the important components during the preparation of a 24x7 project. Approximately 55 DMA's (District metering areas) shall be required in each service area to monitor various parameters like flow, pressure & quality.

Calibration of distribution network

Regular monitoring of flow-pressure data will help to calibrate the system during daily operation and also during maintenance/breakdown.

IoT-based system for continuous supply

Various IOT (internet of things) resources shall be required to be integrated with SCADA to maintain the proper data and forward the required data to authorized users.

4.1 Results and discussions about reducing the losses to 15%

A Pareto chart representing the percentage of non-revenue water is shown below. Of all the losses, the underground water leakages contribute the most, which is 43%. Leakages due to damaged pipelines add up to 29% and leakages due to slums and stand posts contribute to 14%. 88% of the losses are due to these three reasons whereas other minor losses such as illegal connections, unmetered connections, NRW generated from government buildings etc. add up to the remaining 12% of the new.

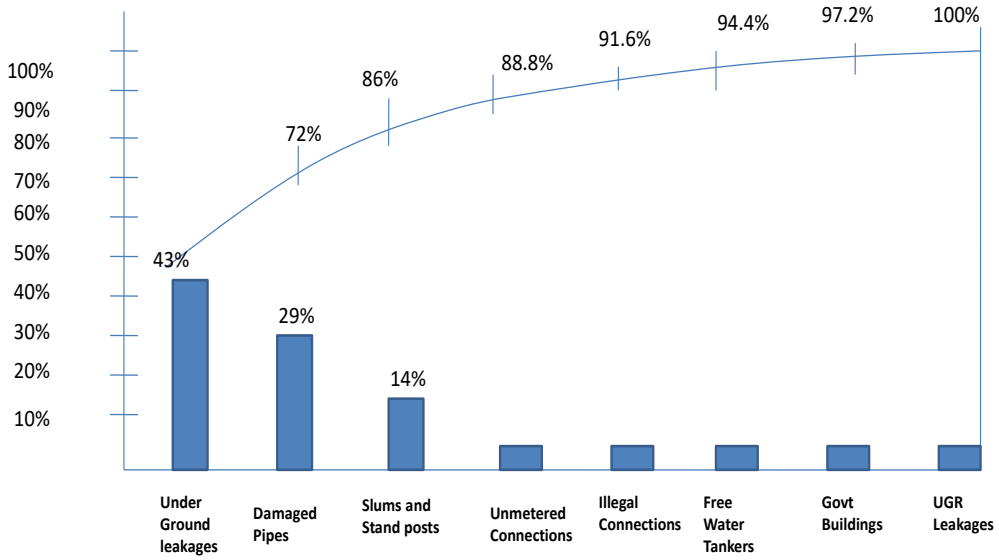

Figure 2. Pareto graph for NRW consumption

As per research, water available - 300 MGD

Table 2. Reduction of losses from 35% to 15%

Water available – 300 MGD per day	Losses at present 35%
In case of losses reduced from present 35% to 15% i.e. reduction in loss by 20%	
Water availability – 300 MGD + 20% of 300 MGD = 360MGD	

Hence, by reducing the losses from 35% to 15%, the water availability will increase by 60 MGD. (Sanjeev Chauhan et al., 2022)

4.2 Using Tertiary Treated Water for Non-domestic Purposes

There is enough advancement in technology today that makes it possible not only to recycle water but to get it under the desired parameters. Water reuse shall become increasingly important in the years ahead to meet the water crisis in areas where only nondomestic water is required. From the data collected, Chandigarh City currently produces more than 50 million litres per day of treated water and holds the capacity to produce much more treated water than the current data received. The collected data also shows that there is a high variation in water usage between the northern and southern sectors of Chandigarh. One such reason for this variation is the usage of potable water in the northern sectors in their personal lawns and gardens. The use of tertiary treated water in such a case can help lower the difference in water usage between the northern and southern sectors and thus help further sustain potable water for other purposes.

5. Conclusion

The current usage of Chandigarh residents is 225 to 245 LPCD which is much higher than the 150 LPCD norms prescribed by CPHEEO norms. The introduction of continuous water supply using surface water alone can aid in saving groundwater, provided the 35% losses are also reduced. The groundwater data as observed shows a decline of almost 7% i.e. from 89% to 81 % from 2017 to 2022. However, to conserve groundwater for future generations, this is still not enough. The use of surface water to meet the 150 LPCD norms by reducing water leakages and non-revenue water can further help in attaining the objective of eliminating the dependency on groundwater. Also, the potable water used mostly in northern sectors for personal lawns and gardens can be replaced by either shallow aquifers, so as to keep the deep aquifers safe from any misuse or either treated water can be used for non-domestic purposes. The use of a continuous water supply using surface water alone can be an aid to preserve groundwater for future use.

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