Water Savings & Reduction of Costs Through the Use of Dual Water Supply System in A Sports Facilities

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Abstract— In sustainable urban management, rainwater, greywater, and groundwater are increasingly being considered as alternative water sources where quality drinking water is not required for the water supply. Current technological solutions allow for the use of dual water supply systems in both private and public buildings. The latter, due to the potential to better manage an alternative water source in a sustainable manner, are recommended for larger scale use.

Indexed Terms-- Conservation of Water, Cost Analysis, Dual Water Supply System, Effluent Treatment Plant, Water Recharge Mechanism.

I. INTRODUCTION

Water occurs as a liquid on the surface of Earth under normal conditions, which makes it invaluable for transportation, for recreation, and as a habitat for a myriad of plants and animals. The fact that water is readily changed to a vapor (gas) allows it to be transported through the atmosphere from the oceans to inland areas where it condenses and, as rain, nourishes plant and animal life. Properties which are supplied or have access to both standard drinking water and recycled water. Two separates, underground, piped water systems that serve a parcel of land or lot characterize dual water systems. As the name implies, dual distribution systems involve the use of water supplies from two different sources in two separate distribution networks. The two systems work independently of each other within the same service area.

Dual distribution systems are usually used to supply potable water through one distribution network and non-potable water through the other. The systems would be used to augment public water supplies by providing untreated, or poorly treated, water for purposes other than drinking. Such purposes could include fire-fighting, sanitary flushing, street cleaning, or irrigation of ornamental gardens or lawns. This system has been used in only two cities in India Thiruvananthapuram and Kota -get continuous dual water supply system.

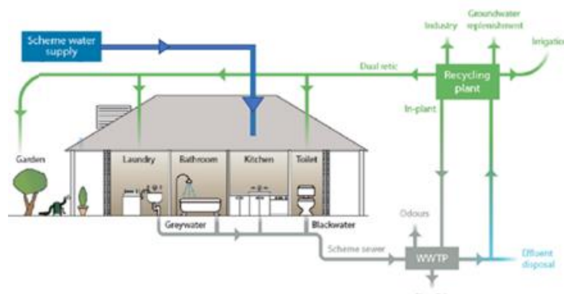


Fig. 1.1 Dual water supply system

The systems are designed as two separate pipe networks: a potable water distribution system, and a system capable of distributing sea water or other non-potable waters. The system includes distribution pipes, valves, hydrants, standpipes, and a pumping system, if required. Pipes in the systems are generally cast iron or ductile iron, although fiberglass has also been used. The cost of constructing a new distribution system for seawater (capital costs) would be similar to that for laying regular distribution pipelines. In effect, the installation of a dual distribution system approximately doubles the cost of construction of the distribution system, although some savings may be achieved if the two systems are installed at the same time (instead of in series, with the non-potable system retrofitted into an existing distribution system).

- Advantages of DWSS

This technology allows the use of cheaper sources of water for non-consumptive purposes, which may currently be served from more expensive, and limited, potable water supplies.

If used to augment the regular distribution system, it makes more potable water available to the general public.

- Disadvantages of DWSS

A dual distribution system requires that two distribution systems have to be installed, at essentially double the cost of a single system.

Having non-potable water in a distribution system creates a potential to cross-contaminate the potable water system (while this is of limited concern in seawater systems, accidental consumption of non-potable water from wastewater-based systems could have serious consequences).

II. INTRODUCTION TO SPORTS FACILITY

Sports facilities means enclosed areas of sports pavilions, stadiums, gymnasiums, health spas, boxing arenas, swimming pools, roller and ice rinks, billiard halls, bowling alleys, and other similar places where members of the general public assemble to engage in physical exercise, participate in athletic competition, or witness sporting events.

A sports complex is a group of sports facilities. For example, there are track and field stadiums, football stadiums, baseball stadiums, swimming pools, and Indoor arenas. This area is a sports complex, for fitness. Olympic Park is also a kind of Entertainment complex. For this case study KD Singh Babu Stadium is selected which was established in 1957.

III. INTRODUCTION TO ETP

ETP (Effluent Treatment Plant) is a process design for treating the industrial waste water for its reuse or safe disposal to the environment.

- Influent: Untreated industrial waste water.
- Effluent: Treated industrial waste water.
- Sludge: Solid part separated from waste water by ETP.

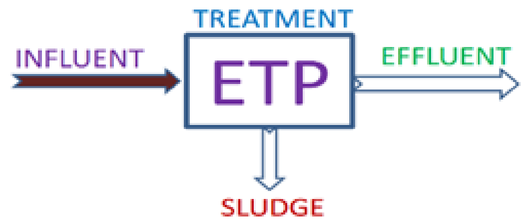


Fig. 1.2 Effluent Treatment Plant

IV. LITERATURE REVIEW

1. Water savings and reduction of costs through the use of a dual water supply system in a sports facility by Ewa Burszta-Adamiak a & Paweł Spychalski (2021)

i. In his study he saved about 70% of fresh water in a sports complex.

ii. For these reasons, the help of the state or at least the local authorities, in providing aid in the form of subsidies, tax exemptions, or even technical advice is essential.

2. Development of dual water supply using rooftop rainwater harvesting and groundwater systems by Siti Nazahiyah Rahmat 1 & Adel Ali Saeed Al Gheethi1 (2019)

In his study, the main aim of this study was to adopting the RWH system and groundwater abstraction as part of the conservation of natural water resources. This has also been investigated in some countries such as in France and Vietnam and successfully implemented. To determine the collection efficiencies of RWH system, a comparison between the actual rainwater that can be harvested and the observed harvested rainwater was made.

3. Trends in dual water systems by Peter D. Rogers & Neil S. Grigg (Nov. 2014)

i. The study concluded that the primary motivators in using dual systems are to extend water supplies and provide more options for wastewater management.

ii. While dual systems can provide benefits such as extending the lives of existing potable water systems and deducing risk from drought, there are many issues such as storage for non-potable supplies, rate-setting, and true costs accounting that remain to be resolved.

4. Design of dual water supply system using rainwater and groundwater at arsenic contaminated area in Vietnam by Duc Canh Nguyen & Moo Young Han (2014)
i. A rainwater harvesting (RWH) system can obtain optimal performance by changing the demand for water use according to rainfall. This model was then used to design a RWH system for Cukhe village.

5. Optimizing rainwater harvesting systems for the dual purposes of water supply and runoff capture by David J., Jia Liu (2014)
i. The RASP (Rainwater analysis and simulation program) simulations have demonstrated differences among land uses stemming from their respective attributes that were assigned and in differences among geographic locations and hydrology. When focused exclusively on water supply unit costs, the most attractive cases appear to be LD (low density residency land) and MD (medium density residency land). COMM (Commercial land usage), OFF (office land uses), and HD (high density residency land), while achieving a relatively highwater supply reliability, achieve the lowest runoff capture costs.

6. Design of Dual Water Supply Systems by R. Chee & K. Lansey (2009)
i. In effort to reduce the amount of water being consumed by people, new engineering technologies are being explored.
ii. Water reuse is becoming recognized as the last untapped water resource. However, little research has been conducted on effectively distributing that water to user. In particular, distribution of reclaimed water through a parallel pipe networks system to homes or dual water supply system has not been considered.

7. Benefits of Shifting Fire Protection to Reclaimed Water by Okun (2009)
i. Okun explained 19th Century decisions to design water distribution systems to provide fire protection as well as to serve commercial properties and residential areas.
ii. He argued that by increasing water age, large diameter distribution systems degrade drinking water quality, which could be improved by distributing potable water in the smaller diameter pipes. By the 1980s, proposals for direct potable reuse of water were emerging, and Okun (1985) was advocating dual systems instead of direct reuse.

8. Institutional analysis of infrastructure problems: case of water quality in distribution system by Grigg, N. (2009)
i. Performance is the main concern of management, and is the indicator that integrates all others, in this case, it integrates effectiveness, cost, and reliability.
ii. Effectiveness is a more specific indicator, which is multi–dimensional and indicates how well a system fulfils its goals.

9. An inexact-stochastic dual water supply programming model by X.H. Zhang, H.W. Zhang (2009)
i. An inexact-stochastic dual water supply programming (ISDWSP) model has been proposed based on ICCP method. The model has been solved by a two-step method, and employed ILP method handling the uncertainties in A and C, while employed CCP method handling the uncertainties in B.

10. Management Practices for Non potable Water Reuse by Mantovani, P., et. al (2001)
i. A WERF study (Mantovani et al. 2001) reviewed 65 non-potable water reuse projects and confirmed that in addition to operational performance, sound institutional arrangements, conservative cost and sales estimates, and good project communication are keys to success.
ii. Institutional obstacles, inadequate valuation of economic benefits, or a lack of public information can hurt projects.

11. Analysis of a rainwater collection system for domestic water supply in Ringdansen, Norrko¨ping, Sweden by Edgar L. Villarreala, Andrew Dixonb (2001)
i. Important water saving efficiencies at Ringdansen are possible if rainwater tanks are included as part of a dual water supply solution, especially if low water consumption appliances are installed. Low flush toilets are available on the Swedish market with flush volumes between one and two liters that may be installed to achieve high WSE and promote water conservation.

12. The Recognition of Drought and its Driving Mechanism based on "Natural-artificial" Dual Water Cycle by FENG Jing, WENG Baish (2001)
i. Under the combined actions by climate change and human activity, there is a new trend of drought that the frequency and influenced areas increase. This paper defines the drought is a dynamic phenomenon that water supply cannot meet the water demand from the "natural-artificial" binary water cycle based on the natural rhythms acted by the climate change and human activity.

13. Water Route: A model for cost optimization of industrial water supply networks when using water resources with varying salinity by Joeri Willet a, Koen Wetser, Jouke E. Dykstra (1997)
i. Water Route is a valuable tool for planning and design of water supply networks using local alternative water sources. Water Route designs water supply networks that deliver water at the specified quality and quantity of the user based on the modelled or known availability of water resources in a region.

14. Fluorescence analysis of centralized water supply systems: Indications for rapid cross-connection detection and water quality safety guarantee by Sihan Pan, Xiaowen Chen, Chenyue Cao. (1992)
i. This study conducted water quality analyses of reclaimed and drinking water samples in several locations of China with an emphasis of fluorescence techniques. Notably, the fluorescence EEM is found to be effective in terms of high sensitivity (i.e., 6-31 times of reclaimed to drinking water in analyzed samples at all FRI regions) and low detection limit under a small proportion of 20% reclaimed water blending. This offers possible indications for cross connection contamination of reclaimed water (i.e., secondary and tertiary effluent) with drinking water.

15. Tertiary treatment and dual disinfection to improve microbial quality of reclaimed water for potable and non-potable reuse: A case study of facilities in North Carolina by Emily S. Bailey a, Lisa M. Casanova, Otto D. Simmons III (1992)
i. From these results, it is not clear that tertiary treated and dual disinfected reclaimed water, treated according to North Carolina requirements meets the log10 reduction performance targets.
ii. High concentrations of adenoviruses were detectable in the tertiary treated dual disinfected reclaimed water by both direct qPCR gene copies and by ICC-qPCR infectivity and the specified 5 log10 reduction target was not met.

16. DUAL WATER DISTRIBUTION SYSTEMS IN CHINA by Chunping Yang, Zhiqiang Shen, Hong Chen, Guangming Zeng (2007)
i. Dual water distribution systems are installed in hotels and newly-built residential districts. With the development of technology for the dual water distribution system, cost of highquality drinking water supplied will dropped in the future.
ii. It can be expected that the dual water distribution systems will be extended to schools, business districts, and hospitals etc. Construction of the dual water distribution system is in accordance with the present situation in China.

V. OBJECTIVES

The concept of sustainable development, including water management, is also referred to in the most important legislative documents at the national level. The purpose of this study is to quantify the potential of harvesting water through assessment of the real possibilities of using rainwater for utility purposes with reference to a dual water supply system operating in a sports facility.

The main objectives of this study are as follows:
1. 1.To analyze the present water supply status.
2. 2.To estimate the cost of dual water supply system.
3. 3.To estimate the water saving & cost analysis.
4. Propose the additional water recharge mechanism.

VI. METHODOLOGY

A. To analyze the present water supply status.

i. Last 5 years data of water consumption is collected from various sports facilities of KD Singh Babu Stadium that is 327.09 KLD. There are two pump houses in the stadium separated with a distance of 143m. Distribution length connected with pump hose 1 is 2.53 km and with pump house 2 is 2.12 km. Daily demand of 40.94 KLD has to be fulfill by pump house 1 with submersible pump capacity of 2.5 Hp. Daily demand of 286.15 KLD has to be fulfill by pump house 2 with submersible pump capacity of 10 Hp. Pumping hours for both pumps are 8 hrs. with design efficiency of 60%. Pump 1 has 35 m head and Pump 2 has 30 m head. Distribution pipe material is DI K-7 with 80mm dia., 100 mm dia. & 125 mm dia.

ii. Total demand of stadium is 327.09 KLD, this total demand is fulfilled by pump house 1 & pump house 2. According to the 5 yr. data of stadium 1.88 KLD is diverted to sewer lines. 255.50 KLD is diverted to Gomti river without any treatment. 69.71 KLD is used in water recharge works that in sprinkling stadium ground and gardening work.

iii. Cost pumping of last 5 year found to be

B. To estimate the cost of dual water supply system.

i. Per day 255.50 KLD water can be conserved and reused.

ii. In this case study we have proposed a ETP (Effluent Treatment Plant), 255.50 KLD water is diverted to ETP and capacity of ETP is designed by considering 16hr. pumping, total outlet and inlet losses of 2%. The capacity is found to be 400 KLD.

iii. 2 EPT is proposed in DWSS of capacity 100KLD & 300 KLD. 100 KLD ETP is attached to pump house 1 distribution network and 300 KLD ETP is connected to distribution network of pump hose 2.

iv. ETP 1 has to fulfill the demand of 255.50 KLD & ETP 2 has to fulfill the demand of 40.94 KLD.

v. Cost of 100 KLD & 300 KLD is found to be 39.99 L including transportation, installation & GST.

vi. A parallel pipe is assumed with old exiting pipe i.e., 2.64 km & 2.20 km attached with ETP 1 & ETP 2. Total distribution is 4.84 km is required for both ETP but it found that we can use some exiting pipe of length 2.65 km can be used, so total distribution network required is 2.19 km. Material used for laying is HDPE pipes with varying dia. of 75 mm, 90 mm & 110 mm. Cost of distribution is found to be 6.66 L.

vii. Capacity of 2 Hp motor is considered by assuming 8hr. pumping with 60% efficiency & 17.31 m head.

viii. Capacity of 20 Hp motor is considered by assuming 8hr. pumping with 60% efficiency & 75.51 m head.

ix. Both ETP consist of 2 & 2 motors of capacity 2Hp & 20 Hp used at inlet and outlet of ETP. Cost of motors is found to be 6.62 L.

x. According to Water GeM report no. of valves are found to be 6 sluice valves, 6 air valves & 4 scour valves which overall cost 6.13 L

xi. Operation cost of ETP motors for next 5 years are estimated as 35.40 L.

xii. Total cost of installation of DWSS in KD Singh Babu Stadium is 59.40 L which includes (ETP installation, Cost of distribution of HDPE PN-6, Installation of valves & Cost of motor) with 5 yrs. operation cost of motor 35.40 L.

C. To estimate the water saving & cost analysis.

i. As per the data it found that daily consumption of ground water in stadium is 327.09 KLD & 255.50 KLD is being wasted, total water is pumped by 2.5 Hp & 10 Hp motor @ 16hrs. pumping daily, which cost 2.01 L

ii. After proposal of ETP it is found that 255.50 KLD water can be recycled and reused in stadium. This 255.50 KLD is diverted to ETP and at the inlet point 1% of waste water is considered in losses, i.e., 252.94 KLD is available for treatment and during treatment process 0.5% water is lost and remaining water available after treatment is 251.68 KLD.

iii. Now to fulfill the demand extra water is needed (327.09 KLD – 251.68 KLD = 75.41 KLD). This 75.41 KLD is pumped by submersible pump of pump house 2 whose capacity is designed on 286.15 KLD demand. Per day we can save (251.68 KLD – 75.41 KLD = 176.27 KLD)

iv. After installation ETP there is no load on pump house 1. Pump house 2 an fulfill the demand by operating 2.11hrs. Pumping hour is reduced from 16 hrs. to 2.11 hrs.

v. Operation Cost of pumping is reduced from 2.01 L to 0.42 L annually.

vi. Operation cost analysis of ETP is considered on the basis that it has to produce the treated water of 251.68 KLD. The pumping hrs. of ETP is 8hrs each, which cost 7.08 L annually.

D. To estimate the water saving & cost analysis.

i. In Uttar Pradesh, Jal Jeevan Mission is going on under the Ministry of Jal Shakti. The aim of this mission is to provide fresh water to each and every household of villages by any surface source of water or any ground water source.

ii. The provision of water recharge mechanism is made by central government to save guard the ground water table in order to provide quality and desired amount of water.

iii. The executing body State Water & Sanitation Mission with collaboration of Uttar Pradesh Jal Nigam Grameen & Minor Irrigation has finalized the rate of water recharge mechanism.

iv. Water recharge mechanism in KD Singh Babu Stadium then will cost 14.29 L

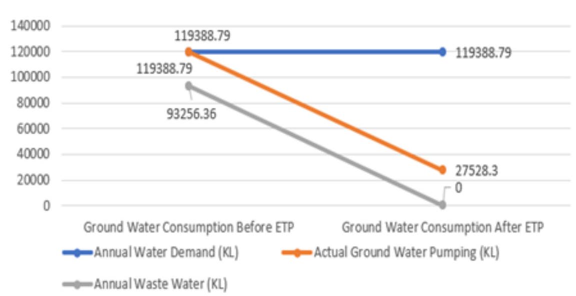
S.No.	Item Description	Qty.	L	B	Area	Rate	Unit	Amount
1.	Water recharge mechanism near swimming pool	1.00	4 m	4 m	16 m^2	89,285.71	Sqm.	**14,28571.36 Or 14.29 L**

Fig. 1.3 Effluent Treatment Plant

CONCLUSION

i. In this study, it is found that new technique of dual water supply system increases the operation cost of water supply from 10.06 L to 37.52 L.

ii. Per day we can save (251.68 KLD – 75.41 KLD = 176.27 KLD)



REFERENCES

[1] Ewa Burszta-Adamiak a & Paweł Spychalski (2021) "Water savings and reduction of costs through the use of a dual water supply system in a sports facility"

[2] Siti Nazahiyah Rahmat 1 & Adel Ali Saeed Al Gheethi1 (2019) "Development of dual water supply using rooftop rainwater harvesting and groundwater systems"

[3] Peter D. Rogers & Neil S. Grigg (Nov. 2014) "Trends in dual water systems"

[4] Duc Canh Nguyen & Moo Young Han (2014) "Design of dual water supply system using rainwater and groundwater at arsenic contaminated area in Vietnam"

[5] David J., Jia Liu (2014) "Optimizing rainwater harvesting systems for the dual purposes of water supply and runoff capture"

[6] R. Chee & K. Lansey (2009) "Design of Dual Water Supply Systems"

[7] Okun (2009) "Benefits of Shifting Fire Protection to Reclaimed Water"

[8] Grigg, N. (2009) "Institutional analysis of infrastructure problems: case of water quality in distribution system"

[9] X.H. Zhang, H.W. Zhang (2009) "An inexact-stochastic dual water supply programming model"

[10] Mantovani, P., et. al (2001) "Management Practices for Non potable Water Reuse"

[11] Edgar L. Villarreala, Andrew Dixonb (2001) "Analysis of a rainwater collection system for domestic water supply in Ringdansen, Norrko¨ping, Sweden"

[12] FENG Jing, WENG Baish (2001) "The Recognition of Drought and its Driving Mechanism based on "Natural-artificial" Dual Water Cycle"

[13] Joeri Willet a, Koen Wetser, Jouke E. Dykstra (1997) "Water Route: A model for cost optimization of industrial water supply networks when using water resources with varying salinity"

[14] Sihan Pan, Xiaowen Chen, Chenyue Cao. (1992) "Fluorescence analysis of centralized water supply systems: Indications for rapid cross-connection detection and water quality safety guarantee"

[15] Emily S. Bailey a, Lisa M. Casanova, Otto D. Simmons III (1992) "Tertiary treatment and dual disinfection to improve microbial quality of reclaimed water for potable and non-potable

reuse: A case study of facilities in North Carolina"

[16] Chunping Yang, Zhiqiang Shen, Hong Chen, Guangming Zeng (2007) "DUAL WATER DISTRIBUTION SYSTEMS IN CHINA"