Industrial Engineering Journal
ISSN: 0970-2555
Volume: 52, Issue 7, No. 1, July: 2023

# WATER SAVINGS & REDUCTION OF COSTS THROUGH THE USE OF SOLAR BASED SYSTEM IN A SPORTS FACILITIES

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**Abstract**

*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 isreadily 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.The major goal of this work is toconserve the fresh ground water with the help of dual water supply system including distribution network and water treatment unit. In this study it is found that initial cost of project is high but in long term it is economical and eco-friendly. New technique of dual water supply system increases the operation cost of water supply from*
*10.06 L to 37.52 L.Per day we can save 176.27 KLD of water in KD Singh Babu Stadium.*

## 1. Introduction

**Water**, a substance composed of the chemical elements hydrogen and oxygen and existing in gaseous, liquid, and solid states. It is one of the most plentiful and essential of compounds. A tasteless and odorless liquid at room temperature, it has the important ability to dissolve many other substances. Indeed, the versatility of water as a solvent is essential to living organisms.

## 2. Techniques for Water Conservation

- Greywater Recycling Systems
- Rainwater Harvesting
- Efficient Irrigation Technology
- Water Meters
- Pressure Reducing Valves
- Insulated Pipes
- Dual Water Supply System (DWSS)
- Solar Based System

### 2.1 Dual Water Supply System (DWSS)

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.

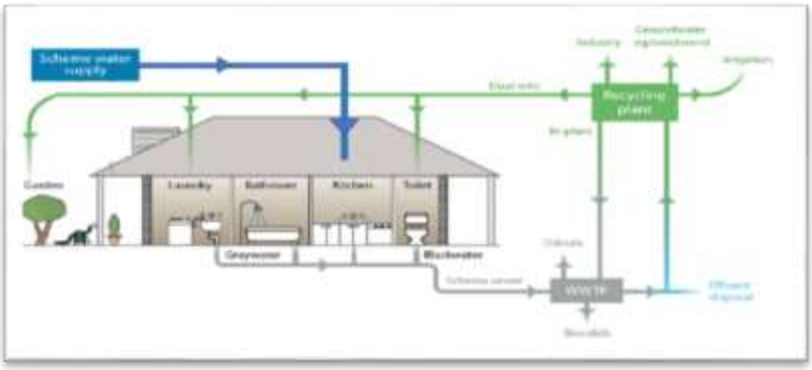



**Fig. 1.1** Dual water supply system

As shown in fig.1.1, the use of tap water for purposes that do not require drinking water, as in toilet flushing, cleaning of pavement, watering lawns and gardens, is neither environmentally nor economically justified.

### 2.2 Solar Based System

The Sun's rays fall on the collector panel (a component of solar water heating system). A black absorbing surface (absorber) inside the collectors absorbs solar radiation and transfers the heat energy to water flowing through it. Heated water is collected in a tank which is insulated to prevent heat loss. Circulation of water from the tank through the collectors and back to the tank continues automatically due to thermo siphon system. Based on the collector system, solar water heaters can be of two types: A solar water heater consists of a collector to collect solar energy and an insulated storage tank to store hot water. The stored hot water can be used later any time.

## 3. Types of Dual Water Supply System

The dual supply might be termed **"potable"** supply and **"non-potable"** supply.Dual water distribution systems usestypical drinking water and highquality drinking water that are each supplied through separate pipe networks. A dual water supply system is defined as one consisting of both a public water network and an onsite rainwater harvesting system that provide sustainable water for **potable and non-potable purposes, respectively.**

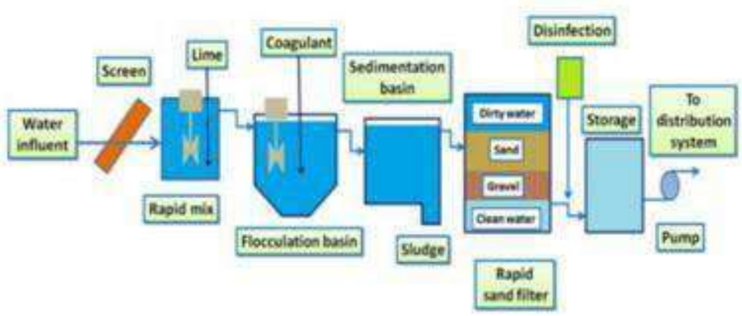
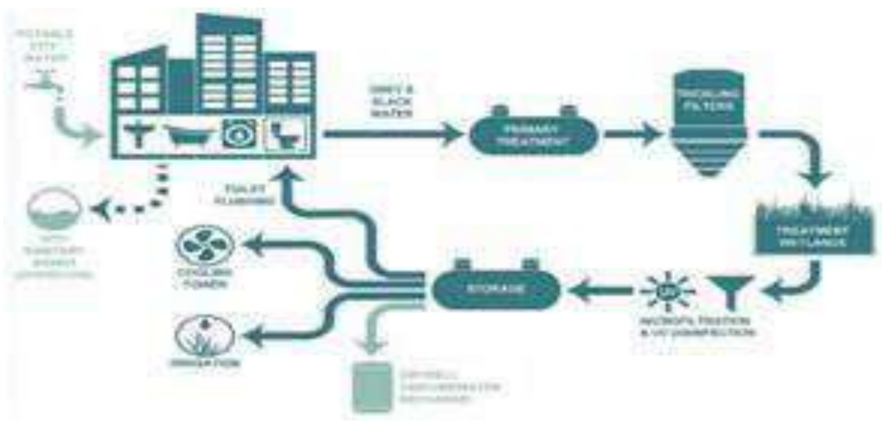



**Fig. 1.2** Potable water treatment process

In the literature, despite the same assumption (dual supply), there are different definitions of these systems. considered the dual water distribution system as one consisting of both rainwater and groundwater.

**Fig. 1.3** Non-Potable water treatment process



## 5. Operation and Maintenance of Dwss

Depending on the use (i.e., intermittent use in the case of fire-fighting supplies or regular in the case ofirrigation supplies) and water source used (e.g., seawater or wastewater), in the dual

The technology is suitable only in distribution system, regular testing of the system is recommended.

## 6. Cost of Dwss

The cost of constructing a new distribution system for seawater (capital costs) would be similar to that forlaying regular distribution pipelines.

## 7. Suitability of Dwss

Areas where a supply of raw water is available. This type of system is generally used near the coast whereseawater is abundant, or in places where wastewater is readily available as a source of supply.

Industrial Engineering Journal
ISSN: 0970-2555
Volume: 52, Issue 7, No. 1, July: 2023

## 8. ADVANTAGES &DISADVANTAGES OF DWSS

### 8.1Advantages

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

### 8.2 Disadvantages

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

## 10.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.

In this case study, KD Singh Babu Stadium has been taken as a sports complex which has many sports facilities inside it like stadiums, gymnasiums, boxing arenas, swimming pools, Boxing Arena, etc. as shown in fig. 1.4. The function of a dual water supply system operating in a sports facilitywas evaluated on the basis of technical, quantitative and financial data.

**Fig. 1.4** KD Singh Babu Stadium Sports Complex

For treatment of water dual water system needs a treatment unit like Water Treatment Plant (WTP) or Effluent Treatment Plant (ETP). This case study is performed on ETP be because waste water is less than compared to WTP.

## 11. INTRODUCTION TO ETP

ETP (Effluent Treatment Plant) is a process design for treating theindustrial waste water for its reuse or safedisposal to theenvironment as shown in fig. 1.5.

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

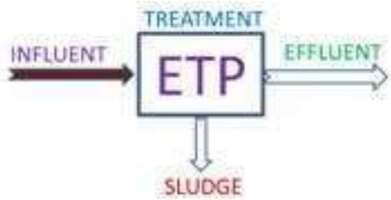



**Fig. 1.5**ETP Flow Chart

## Literature Review

In order to fulfil the aims and objectives of the present study following literatures have been reviewed.

### 2.1General

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. In this article, the function of a dual water supply system operating in asports facility, including the collection and use of rainwater for non-potable purposes, was evaluated on thebasis of technical, quantitative and financial data.

### 2.2 LITERATURE REVIEW

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

**2.2.2.** Development of dual water supply using rooftop rainwater harvesting and groundwater systems bySiti Nazahiyah Rahmat 1 &Adel Ali Saeed Al-Gheethi1 (2019)

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

**2.2.4.** Design of dual water supply system using rainwater and groundwater at arsenic contaminated area inVietnam by Duc Canh Nguyen & Moo Young Han (2014)

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

2.2.12. The Recognition of Drought and its Driving Mechanism based on "Natural-artificial" Dual Water Cycleby FENG Jing, WENG Baish (2001)

2.2.13. 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)

2.2.14. 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)

2.2.15. 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)

2.2.16. DUAL WATER DISTRIBUTION SYSTEMS IN CHINA by Chunping Yang, Zhiqiang Shen, HongChen, Guangming Zeng (2007)

## 2.3PROBLEM STATEMENT

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

## 2.4 Objectives

**The Main Objectives of This Study are as Follows:**

1. To analyze the present water supply status.
2. To estimate the cost of dual water supply system.
3. To estimate the water saving & cost analysis.
4. Propose the additional water recharge mechanism.

## Research & Methodology

## 3. Methodology

The methodology contains with case study of sport facility of K.D Singh Babu Stadium including data collection of site location, Analysis of data, Providing Optimal Solution, Future aspect, Result, Conclusion and Future.

### 3.1 Selecting Site Location of Sport Facility.

**Fig. 3.1** Google image of K D Singh Babu Stadium

Industrial Engineering Journal
ISSN: 0970-2555
Volume: 52, Issue 7, No. 1, July: 2023

### 3.2 About Sport Facility

- The KD Singh Babu Stadium, formerly known as the Central Sports Stadium, is a multi-purpose stadium named after the famous hockey player K. D. Singh. Some important points of stadium are given below.

**Table 3.1:** About K D Singh Babu Stadium

| Sport Facility Name | : | K D Singh Babu Stadium |
|---|---|---|
| Location | : | Hazratganj, Lucknow, U.P., India. |
| Maximum Capacity | : | 25,000 |
| Establishment | : | 1957 |
| Owner | : | UPCA (Uttar Pradesh Cricket Association) |
| Present RSO | : | Ajay Kumar Sethi |

### 3.3 DATA COLLECTION

#### 3.3.1. Annual **Ground Water Consumption by K D Singh Babu Stadium 2017**

| Total Water Consumed in 2017 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| S.No. | List of Sports Facility | Avg. Annual water entered in sports facility KL | Annual water consumed for drinking KL | Avg. Annual water consumed in toilets KL | Annual water consumed for other works KL | Avg. Annual water consumed for water recharge works KL | Annual waste water discharged in Gomti River in KL | Avg. Annual waste water discharged in Sewer line in KL | |
| 1 | Staff Quarter | 5,491.07 | 15.30 | 0.77 | 5,475.00 | - | 5,475.00 | 16.07 | |
| 2 | Swimming Pool | 81,554.63 | 2.50 | 0.13 | 81,552.00 | - | 81,552.00 | 2.63 | |
| 3 | Indoor Facility | 6.47 | 3.30 | 0.17 | 3.00 | - | 3.00 | 3.47 | |
| 4 | Tennis Court | 161.70 | - | - | 161.70 | - | 161.70 | - | |
| 5 | Badminton Court | 215.40 | 4.00 | 0.20 | 211.20 | - | 211.20 | 4.20 | |
| 6 | Volleyball Court | 128.70 | - | - | 128.70 | 128.70 | - | - | |
| 7 | Cricket Practice Area | 10.80 | - | - | 10.80 | 10.80 | - | - | |
| 8 | Weight Lifting Hall | 84.24 | 4.80 | 0.24 | 79.20 | - | 79.20 | 5.04 | |
| 9 | Taekwondo Hall | 114.93 | 2.60 | 0.13 | 112.20 | - | 112.20 | 2.73 | |
| 10 | Gymnasium | 103.31 | 7.25 | 0.36 | 95.70 | - | 95.70 | 7.61 | |
| 11 | Basketball Court | 211.20 | - | - | 211.20 | - | 211.20 | - | |
| 12 | Boys & Girls Hostels | 218.16 | 139.20 | 6.96 | 72.00 | - | 72.00 | 146.16 | |
| 13 | Boys & Girls Mess | 128.00 | 116.00 | 5.80 | 6.20 | - | 6.20 | 121.80 | |
| 14 | Guard Rooms | 4.70 | 2.88 | 0.14 | 1.68 | - | 1.68 | 3.02 | |
| 15 | 4 Gardens | 28.80 | - | - | 28.80 | 28.80 | - | - | |
| 16 | Public Toilets | 18.15 | - | - | 18.15 | - | 18.15 | - | |
| 17 | Sprinklers | 25,272.00 | - | - | 25,272.00 | 25,272.00 | - | - | |
| 18 | Boxing Arena | 142.07 | 3.30 | 0.17 | 138.60 | - | 138.60 | 3.47 | |
| 19 | Martial Art Area | 158.12 | 2.88 | 0.14 | 155.10 | - | 155.10 | 3.02 | |
| 20 | Store Room | 104.03 | 1.65 | 0.08 | 102.30 | - | 102.30 | 1.73 | |
| 21 | Office | 264.66 | 13.20 | 0.66 | 250.80 | - | 250.80 | 13.86 | |
| 22 | Public Water tank | 315.00 | 300.00 | 15.00 | - | - | - | 315.00 | |
| 23 | Admin. Office | 179.85 | 33.00 | 1.65 | 145.20 | - | 145.20 | 34.65 | |
| | Total Water Consumed | 1,14,915.98 | 651.86 | 32.59 | 1,14,231.53 | 25,440.30 | 88,791.23 | 684.45 | KL |
| | | 114.92 | 0.65 | 0.03 | 114.23 | 25.44 | 88.79 | 0.68 | ML |

**Table 3.2:** Water consumed in year of 2017

#### 3.3.2. Annual Ground Water Consumption by K D Singh Babu Stadium 2018

**Table 3.3:** Water consumed in year of 2018

| Total Water Consumed in 2018 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| S.No. | List of Sports Facility | Avg. Annual water entered in sports facility KL | Annual water consumed for drinking KL | Avg. Annual water consumed in toilets KL | Annual water consumed for other works KL | Avg. Annual water consumed for water recharge works KL | Annual waste water discharged in Gomti River | Avg. Annual waste water discharged in Sewer line in KL | |
| 1 | Staff Quarter | 5,416.70 | 15.90 | 0.80 | 5,400.00 | - | 5,400.00 | 16.70 | |
| 2 | Swimming Pool | 86,651.73 | 2.60 | 0.13 | 86,649.00 | - | 86,649.00 | 2.73 | |
| 3 | Indoor Facility | 6.62 | 3.35 | 0.17 | 3.10 | - | 3.10 | 3.52 | |
| 4 | Tennis Court | 158.40 | - | - | 158.40 | - | 158.40 | - | |
| 5 | Badminton Court | 211.89 | 3.80 | 0.19 | 207.90 | - | 207.90 | 3.99 | |
| 6 | Volleyball Court | 127.05 | - | - | 127.05 | 127.05 | - | - | |
| 7 | Cricket Practice Area | 10.26 | - | - | 10.26 | 10.26 | - | - | |
| 8 | Weight Lifting Hall | 83.42 | 4.65 | 0.23 | 78.54 | - | 78.54 | 4.88 | |
| 9 | Taekwondo Hall | 111.36 | 2.34 | 0.12 | 108.90 | - | 108.90 | 2.46 | |
| 10 | Gymnasium | 101.66 | 7.25 | 0.36 | 94.05 | - | 94.05 | 7.61 | |
| 11 | Basketball Court | 209.55 | - | - | 209.55 | - | 209.55 | - | |
| 12 | Boys & Girls Hostels | 212.64 | 136.80 | 6.84 | 69.00 | - | 69.00 | 143.64 | |
| 13 | Boys & Girls Mess | 125.28 | 114.00 | 5.70 | 5.58 | - | 5.58 | 119.70 | |
| 14 | Guard Rooms | 4.57 | 2.64 | 0.13 | 1.80 | - | 1.80 | 2.77 | |
| 15 | 4 Gardens | 32.40 | - | - | 32.40 | 32.40 | - | - | |
| 16 | Public Toilets | 16.50 | - | - | 16.50 | - | 16.50 | - | |
| 17 | Sprinklers | 24,105.60 | - | - | 24,105.60 | 24,105.60 | - | - | |
| 18 | Boxing Arena | 140.76 | 3.63 | 0.18 | 136.95 | - | 136.95 | 3.81 | |
| 19 | Martial Art Area | 156.85 | 3.24 | 0.16 | 153.45 | - | 153.45 | 3.40 | |
| 20 | Store Room | 105.04 | 1.98 | 0.10 | 102.96 | - | 102.96 | 2.08 | |
| 21 | Office | 272.65 | 14.52 | 0.73 | 257.40 | - | 257.40 | 15.25 | |
| 22 | Public Water tank | 304.50 | 290.00 | 14.50 | - | - | - | 304.50 | |
| 23 | Admin. Office | 171.44 | 36.30 | 1.82 | 133.32 | - | 133.32 | 38.12 | |
| | Total Water Consumed | 1,18,736.86 | 643.00 | 32.15 | 1,18,061.71 | 24,275.31 | 93,786.40 | 675.15 | KL |
| | | 118.74 | 0.64 | 0.03 | 118.06 | 24.28 | 93.79 | 0.68 | ML |

Industrial Engineering Journal
ISSN: 0970-2555
Volume: 52, Issue 7, No. 1, July: 2023

**3.3.3.** Annual Ground Water Consumption by K D Singh Babu Stadium 2019

| Total Water Consumed in 2019 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| S.No. | List of Sports Facility | Avg. Annual water entered in sports facility KL | Annual water consumed for drinking KL | Avg. Annual water consumed in toilets KL | Annual water consumed for other works KL | Avg. Annual water consumed for water recharge works KL | Annual waste water discharged in Gomti River | Avg. Annual waste water discharged in Sewer line in KL |
| 1 | Staff Quarter | 5,453.94 | 14.70 | 0.74 | 5,438.50 | - | 5,438.50 | 15.44 |
| 2 | Swimming Pool | 86,651.84 | 2.70 | 0.14 | 86,649.00 | - | 86,649.00 | 2.84 |
| 3 | Indoor Facility | 5.98 | 2.85 | 0.14 | 2.99 | - | 2.99 | 2.99 |
| 4 | Tennis Court | 163.35 | - | - | 163.35 | - | 163.35 | - |
| 5 | Badminton Court | 219.16 | 5.85 | 0.29 | 213.02 | - | 213.02 | 6.14 |
| 6 | Volleyball Court | 130.35 | - | - | 130.35 | 130.35 | - | - |
| 7 | Cricket Practice Area | 13.23 | - | - | 13.23 | 13.23 | - | - |
| 8 | Weight Lifting Hall | 84.60 | 4.20 | 0.21 | 80.19 | - | 80.19 | 4.41 |
| 9 | Taekwondo Hall | 118.78 | 3.75 | 0.19 | 114.84 | - | 114.84 | 3.94 |
| 10 | Gymnasium | 105.40 | 7.35 | 0.37 | 97.68 | - | 97.68 | 7.72 |
| 11 | Basketball Court | 214.17 | - | - | 214.17 | - | 214.17 | - |
| 12 | Boys & Girls Hostels | 224.67 | 143.40 | 7.17 | 74.10 | - | 74.10 | 150.57 |
| 13 | Boys & Girls Mess | 131.70 | 120.00 | 6.00 | 5.70 | - | 5.70 | 126.00 |
| 14 | Guard Rooms | 6.50 | 3.96 | 0.20 | 2.34 | - | 2.34 | 4.16 |
| 15 | 4 Gardens | 34.56 | - | - | 34.56 | 34.56 | - | - |
| 16 | Public Toilets | 15.68 | - | - | 15.68 | - | 15.68 | - |
| 17 | Sprinklers | 25,272.00 | - | - | 25,272.00 | 25,272.00 | - | - |
| 18 | Boxing Arena | 144.67 | 2.95 | 0.15 | 141.57 | - | 141.57 | 3.10 |
| 19 | Martial Art Area | 161.28 | 3.06 | 0.15 | 158.07 | - | 158.07 | 3.21 |
| 20 | Store Room | 99.57 | 1.80 | 0.09 | 97.68 | - | 97.68 | 1.89 |
| 21 | Office | 278.93 | 12.96 | 0.65 | 265.32 | - | 265.32 | 13.61 |
| 22 | Public Water tank | 325.50 | 310.00 | 15.50 | - | - | - | 325.50 |
| 23 | Admin. Office | 181.86 | 32.40 | 1.62 | 147.84 | - | 147.84 | 34.02 |
|  | **Total Water Consumed** | **1,20,037.70** | **671.93** | **33.60** | **1,19,332.17** | **25,450.14** | **93,882.03** | **705.53 KL** |
|  |  | **120.04** | **0.67** | **0.03** | **119.33** | **25.45** | **93.88** | **0.71 ML** |

**Table 3.4:** Water consumed in year of 2019

**3.3.4.** Annual Ground Water Consumption by K D Singh Babu Stadium 2021

| Total Water Consumed in 2021 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| S.No. | List of Sports Facility | Avg. Annual water entered in sports facility KL | Annual water consumed for drinking KL | Avg. Annual water consumed in toilets KL | Annual water consumed for other works KL | Avg. Annual water consumed for water recharge works KL | Annual waste water discharged in Gomti River | Avg. Annual waste water discharged in Sewer line in KL |
| 1 | Staff Quarter | 5,198.12 | 14.40 | 0.72 | 5,183.00 | - | 5,183.00 | 15.12 |
| 2 | Swimming Pool | 83,695.48 | 2.61 | 0.13 | 83,692.74 | - | 83,692.74 | 2.74 |
| 3 | Indoor Facility | 5.62 | 2.55 | 0.13 | 2.94 | - | 2.94 | 2.68 |
| 4 | Tennis Court | 162.69 | - | - | 162.69 | - | 162.69 | - |
| 5 | Badminton Court | 199.48 | 5.55 | 0.28 | 193.65 | - | 193.65 | 5.83 |
| 6 | Volleyball Court | 118.50 | - | - | 118.50 | 118.50 | - | - |
| 7 | Cricket Practice Area | 11.61 | - | - | 11.61 | 11.61 | - | - |
| 8 | Weight Lifting Hall | 83.67 | 4.26 | 0.21 | 79.20 | - | 79.20 | 4.47 |
| 9 | Taekwondo Hall | 117.57 | 3.54 | 0.18 | 113.85 | - | 113.85 | 3.72 |
| 10 | Gymnasium | 104.82 | 7.05 | 0.35 | 97.42 | - | 97.42 | 7.40 |
| 11 | Basketball Court | 212.88 | - | - | 212.88 | - | 212.88 | - |
| 12 | Boys & Girls Hostels | 223.57 | 142.92 | 7.15 | 73.50 | - | 73.50 | 150.07 |
| 13 | Boys & Girls Mess | 130.50 | 120.00 | 6.00 | 4.50 | - | 4.50 | 126.00 |
| 14 | Guard Rooms | 6.33 | 3.92 | 0.20 | 2.21 | - | 2.21 | 4.12 |
| 15 | 4 Gardens | 34.70 | - | - | 34.70 | 34.70 | - | - |
| 16 | Public Toilets | 15.26 | - | - | 15.26 | - | 15.26 | - |
| 17 | Sprinklers | 28,382.40 | - | - | 28,382.40 | 28,382.40 | - | - |
| 18 | Boxing Arena | 143.36 | 2.81 | 0.14 | 140.42 | - | 140.42 | 2.95 |
| 19 | Martial Art Area | 159.20 | 2.81 | 0.14 | 156.26 | - | 156.26 | 2.95 |
| 20 | Store Room | 98.21 | 1.98 | 0.10 | 96.13 | - | 96.13 | 2.08 |
| 21 | Office | 269.12 | 13.68 | 0.68 | 254.76 | - | 254.76 | 14.36 |
| 22 | Public Water Tank | 299.25 | 285.00 | 14.25 | - | - | - | 299.25 |
| 23 | Admin. Office | 168.84 | 28.80 | 1.44 | 138.60 | - | 138.60 | 30.24 |
|  | **Total Water Consumed** | **1,19,841.19** | **641.88** | **32.09** | **1,19,167.22** | **28,547.21** | **90,620.00** | **673.98 KL** |
|  |  | **119.84** | **0.64** | **0.03** | **119.17** | **28.55** | **90.62** | **0.67 ML** |

**Table 3.5:** Water consumed in year of 2021

**3.3.5.** Annual Ground Water Consumption by K D Singh Babu Stadium 2022

| Total Water Consumed in 2022 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| S.No. | List of Sports Facility | Avg. Annual water entered in sports facility KL | Annual water consumed for drinking KL | Avg. Annual water consumed in toilets KL | Annual water consumed for other works KL | Avg. Annual water consumed for water recharge works KL | Annual waste water discharged in Gomti River | Avg. Annual waste water discharged in Sewer line in KL |
| 1 | Staff Quarter | 5,673.25 | 15.00 | 0.75 | 5,657.50 | - | 5,657.50 | 15.75 |
| 2 | Swimming Pool | 91,749.15 | 3.00 | 0.15 | 91,746.00 | - | 91,746.00 | 3.15 |
| 3 | Indoor Facility | 6.25 | 3.00 | 0.15 | 3.10 | - | 3.10 | 3.15 |
| 4 | Tennis Court | 165.00 | - | - | 165.00 | - | 165.00 | - |
| 5 | Badminton Court | 220.80 | 6.00 | 0.30 | 214.50 | - | 214.50 | 6.30 |
| 6 | Volleyball Court | 132.00 | - | - | 132.00 | 132.00 | - | - |
| 7 | Cricket Practice Area | 13.50 | - | - | 13.50 | 13.50 | - | - |
| 8 | Weight Lifting Hall | 87.23 | 4.50 | 0.23 | 82.50 | - | 82.50 | 4.73 |
| 9 | Taekwondo Hall | 119.60 | 3.90 | 0.20 | 115.50 | - | 115.50 | 4.10 |
| 10 | Gymnasium | 106.88 | 7.50 | 0.38 | 99.00 | - | 99.00 | 7.88 |
| 11 | Basketball Court | 214.50 | - | - | 214.50 | - | 214.50 | - |
| 12 | Boys & Girls Hostels | 226.20 | 144.00 | 7.20 | 75.00 | - | 75.00 | 151.20 |
| 13 | Boys & Girls Mess | 132.00 | 120.00 | 6.00 | 6.00 | - | 6.00 | 126.00 |
| 14 | Guard Rooms | 6.30 | 3.60 | 0.18 | 2.52 | - | 2.52 | 3.78 |
| 15 | 4 Gardens | 36.00 | - | - | 36.00 | 36.00 | - | - |
| 16 | Public Toilets | 16.50 | - | - | 16.50 | - | 16.50 | - |
| 17 | Sprinklers | 23,328.00 | - | - | 23,328.00 | 23,328.00 | - | - |
| 18 | Boxing Arena | 145.68 | 3.60 | 0.18 | 141.90 | - | 141.90 | 3.78 |
| 19 | Martial Art Area | 161.42 | 2.88 | 0.14 | 158.40 | - | 158.40 | 3.02 |
| 20 | Store Room | 100.89 | 1.80 | 0.09 | 99.00 | - | 99.00 | 1.89 |
| 21 | Office | 277.80 | 14.40 | 0.72 | 262.68 | - | 262.68 | 15.12 |
| 22 | Public Water Tank | 312.90 | 298.00 | 14.90 | - | - | - | 312.90 |
| 23 | Admin. Office | 180.36 | 36.00 | 1.80 | 142.56 | - | 142.56 | 37.80 |
|  | **Total Water Consumed** | **1,23,412.20** | **667.18** | **33.36** | **1,22,711.66** | **23,509.50** | **99,202.16** | **700.54 KL** |
|  |  | **123.41** | **0.67** | **0.03** | **122.71** | **23.51** | **99.20** | **0.70 ML** |

**Table 3.6:** Water consumed in year of 2022

### 3.4 Analysis of Annual Water Consumption.

- In last 5 years **114.92 ML, 118.74 ML, 120.04 ML, 119.84 ML & 123.41 ML** water is consumed shown infig. 3.2.

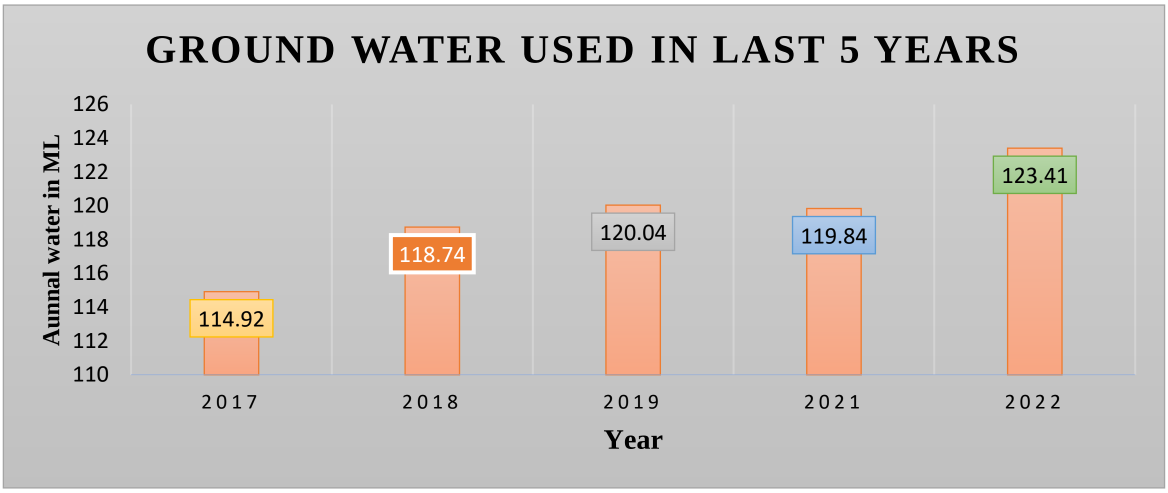



**Fig. 3.2** Comparison of Annual Water Consumption of 5 Years

- On an avg. of 5 years data **93,256.36KL**or **93.26 ML**water is drained in Gomti river without reuse & which can be saved with new technique of dual water supply system every year as shown in table 3.7.

| Average of 5 Years | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| S.No | List of Sports Facility | Avg. Annual water entered in sports facility KL | Avg. Annual water consumed for drinking KL | Avg. Annual water consumed in toilets KL | Avg. Annual water consumed for other works KL | Avg. Annual water consumed for water recharge works KL | Avg. Annual waste water discharged in Gomti River in KL | Avg. Annual waste water discharged in Sewer line in KL | |
| 1 | Staff Quarter | 5,446.61 | 15.06 | 0.75 | 5,430.80 | - | 5,430.80 | 15.81 | |
| 2 | Swimming Pool | 86,060.56 | 2.68 | 0.13 | 86,057.75 | - | 86,057.75 | 2.82 | |
| 3 | Indoor Facility | 6.19 | 3.01 | 0.15 | 3.03 | - | 3.03 | 3.16 | |
| 4 | Tennis Court | 162.23 | - | - | 162.23 | - | 162.23 | - | |
| 5 | Badminton Court | 213.35 | 5.04 | 0.25 | 208.05 | - | 208.05 | 5.29 | |
| 6 | Volleyball Court | 127.32 | - | - | 127.32 | 127.32 | - | - | |
| 7 | Cricket Practice Area | 11.88 | - | - | 11.88 | 11.88 | - | - | |
| 8 | Weight Lifting Hall | 84.63 | 4.48 | 0.22 | 79.93 | - | 79.93 | 4.71 | |
| 9 | Taekwondo Hall | 116.45 | 3.23 | 0.16 | 113.06 | - | 113.06 | 3.39 | |
| 10 | Gymnasium | 104.41 | 7.28 | 0.36 | 96.77 | - | 96.77 | 7.64 | |
| 11 | Basketball Court | 212.46 | - | - | 212.46 | - | 212.46 | - | |
| 12 | Boys & Girls Hostels | 221.05 | 141.26 | 7.06 | 72.72 | - | 72.72 | 148.33 | |
| 13 | Boys & Girls Mess | 129.50 | 118.00 | 5.90 | 5.60 | - | 5.60 | 123.90 | |
| 14 | Guard Rooms | 5.68 | 3.40 | 0.17 | 2.11 | - | 2.11 | 3.57 | |
| 15 | 4 Gardens | 33.29 | - | - | 33.29 | 33.29 | - | - | |
| 16 | Public Toilets | 16.42 | - | - | 16.42 | - | 16.42 | - | |
| 17 | Sprinklers | 25,272.00 | - | - | 25,272.00 | 25,272.00 | - | - | |
| 18 | Boxing Arena | 143.31 | 3.26 | 0.16 | 139.89 | - | 139.89 | 3.42 | |
| 19 | Martial Art Area | 159.38 | 2.97 | 0.15 | 156.26 | - | 156.26 | 3.12 | |
| 20 | Store Room | 101.55 | 1.84 | 0.09 | 99.61 | - | 99.61 | 1.93 | |
| 21 | Office | 272.63 | 13.75 | 0.69 | 258.19 | - | 258.19 | 14.44 | |
| 22 | Public Water Tank | 311.41 | 296.60 | 14.83 | - | - | - | 311.43 | |
| 23 | Admin Office | 176.47 | 33.30 | 1.67 | 141.50 | - | 141.50 | 34.97 | |
| | Total Water Consumed | 1,19,388.79 | 688.17 | 32.76 | 1,18,700.86 | 25,444.49 | 93,256.36 | 687.93 | KL |
| | | 119.39 | 0.66 | 0.03 | 118.70 | 25.44 | 93.26 | 0.69 | ML |

**Table 3.7** Average of 5 Year Water Consumption

### 3.5 Providing Optimal Solution for Water Conservations & Cost Reduction.

- Engineering is the application of science and mathematics to solve problems. Engineers figure out how things work and find practical uses for scientific discoveries. Here, water conservation can be done usingdual water supply system which leads to cost reduction. Techniques.
- In KD Singh Babu Stadium there is **4.65 km** water distribution network from **(Pump House 1, Pump House2)** to each **(Sports Facilities, Hostels, Staff Rooms etc.).** Both pumps of capacity **2 HP& 10 HP** and separated at a distance of **143 m** between them and pumping hours in stadium is **8 hrs.** for each pump.
- The depth of the both borewells are of **34.62 m&29.50 m** as per the data shared by the stadium engineers. **DI K7** pipe is used with **125 mm, 100 mm & 80 mm dia.**
- According to the stadium maintenance team, the depth of the borewell has never been increased since establishment because stadium is located near the **Gomti river**, which recharge its draw down depth.

#### 3.5.1 Techniques for Water Conservation in KD Singh Babu Stadium

- ➢ As per the study we have found that every year **93.26 ML** water is getting wasted and directly drained into the Gomti river. So, in order to save this water, we must treat the water by proposing a ETP inside the stadium complex.
- ➢ **2.20 km** pipe should be laid parallel to the existing pipe line, which will Convey the partial treated water to each sports

facility as per the requirement.

- Size of water recharge pits can vary from **2m x 2m, 4m x 4m** with suitable depth.
- During rainy season water should in collected in desired size of tank, which can be used in stadium.

### 3.5.2 Cost Analysis of Dual Water Supply System

- In this case study we have proposed an **Effluent Treatment Plant (ETP), Distribution Network &Motor pump,** which will increase the initial cost of the dual water supply system and considered major work for cost analysis.

#### 3.5.2.1 Cost Analysis of Effluent Treatment Plant

- Cost of ETP is calculated by taking the reference of Desire Solution & Services, New Delhi.
- As per the data collected from stadium of waste water is **93.26 ML** per year as shown in table no. 3.7. So, the capacity of ETP is analyzed by considering **1% losses of water** on distribution side and **1 % losses of water** from sport facilities to ETP. Pumping hours of stadium is shown in table no. 3.10.

**Table 3.8** ETP Capacity Calculation

| S.No. | Stadium Daily Demand (KLD / MLD) | Water Losses | Pumping Hr. | ETP Capacity |
|---|---|---|---|---|
| 1. | = (93.26 / 365) *1000 = 255.50 KLD or = 0.255 MLD | 2 % Assumed for design of ETP | 16 Hrs. for 2 ETP | **400 KLD** |

- Adopted size of ETP is **400 KLD** which should be installed in stadium for partial treatment.
- Cost analysis of **100 KLD& 300 KLD** capacity ETP is **39.99 lacs.,** including transportation, installation and GST which is manufactured by Riva Appliances Private Limited, Delhi.

#### 3.5.2.2 Cost Analysis of Distribution Network Connected with ETP

- The most important part of dual water supply system is parallel pipe lines which consist of partial treated water.
- Total distribution length of pipes connected with **ETP 1** and **ETP 2** is **4.85 km.**
- According to old survey report data elevation points are considered for laying of new pipe line. Total capacity of new pipe line shown in table no. 3.9 –

**Table 3.9**Pipe Abstract

| S.No. | Description | Design Values |
|---|---|---|
| **1.** | Design Period | 30 Years |
| **2.** | Minimum Terminal Pressure | 7 m for ETP 1 & 12 m for ETP 2 |
| **3.** | Peak Factor | 3 |
| **4.** | Minimum Diameter of Mains | 110 mm, 90 mm & 75 mm |
| **5.** | Pipe Material | HDPE Pipe PE – 100 grade PN – 6 working pressures has been provided. |

- For the cost estimation of distribution pipe rates are considered from State Water & Sanitation Mission.

**Table 3.10** HDPE pipes rates approved by SWSM

| Sr. No. | Pipe Dia. mm | Pipe Class/ Pressure Rating | Cost of Pipe including fittings & specials in Rs./mtr. | Cost for Laying, Jointing & Testing in Rs./ m. | Recommended Rate of Pipe including Fittings,Special, Laying, Jointing & Testing in Rs./ m. |
|---|---|---|---|---|---|
| 1 | 63 | PE 100/PN 6 | 84.15 | 41.65 | 125.8 |
| 2 | 75 | PE 100/PN 6 | 120.73 | 48.47 | 169.2 |
| 3 | 90 | PE 100/PN 6 | 175.07 | 54.43 | 229.5 |
| 4 | 110 | PE 100/PN 6 | 270.62 | 69.29 | 339.9 |
| 5 | 125 | PE 100/PN 6 | 344.98 | 76.87 | 421.8 |
| 6 | 140 | PE 100/PN 6 | 402.33 | 93.82 | 496.2 |
| 7 | 160 | PE 100/PN 6 | 545.21 | 105.50 | 650.7 |
| 8 | 180 | PE 100/PN 6 | 672.25 | 102.96 | 775.2 |
| 9 | 200 | PE 100/PN 6 | 805.72 | 110.21 | 915.9 |

**Pipe Table**

Following table gives the detailed output of the hydraulic design of the KD Singh Babu Stadium obtained from

**Water GEMS.**

- Distribution attached to **ETP 1** consist of **2640.41 m** or **2.64 Km** pipes having various diameter varying from **75 mm** to **110 mm dia**. and varying length.
- Distribution attached to **ETP 2** consist of **2204.85 m** or **2.20 Km** pipes having various diameter varying from **75 mm** to **110 mm dia.** and length.

**Junction Table**

- Maximum and minimum pressure available at **ETP1** are **13 m** and **7 m**& maximum and minimum pressure available at the junctions in this study are**. ETP 2** is **16 m** and **12 m.**

❖ **Cost Analysis of Distribution Network**

- Cost of distribution network is done by considering the required length of pipe as per design report obtained by Water GEM as shown in table no. 3.11. And the rates of various pipe dia. are taken from the Jal Jeevan Mission project under State Water and Sanitation Mission.

**Table 3.11** Cost Analysis of Distribution Network

| Length of Pipe connected to ETP 1 | | | | | Rates | Units | Amount |
|---|---|---|---|---|---|---|---|
| Total length of 75 mm dia. | | | 1,136.71 | m | 169.20 | Per m | 1,92,331.33 |
| Total length of 90 mm dia. | | | 642.78 | m | 229.50 | Per m | 1,47,518.01 |
| Total length of 110 mm dia. | | | 860.92 | m | 339.9 | Per m | 2,92,626.71 |
| Sub Total (B) | | | 2,640.41 | m | | | 6,32,476.05 |
| | | | | | | | |
| Length of Pipe connected to ETP 2 | | | | | Rates | Units | Amount |
| Total length of 75 mm dia. | | | 1,197.83 | m | 169.20 | Per m | 2,02,672.84 |
| Total length of 90 mm dia. | | | 355.29 | m | 229.50 | Per m | 81,539.06 |
| Total length of 110 mm dia. | | | 651.73 | m | 339.9 | Per m | 2,21,523.03 |
| Sub Total (A) | | | 2,204.85 | m | | | 5,05,734.92 |
| Total C = ( A+ B ) | | | 4,845.26 | m | | | 11,38,210.97 |
| Existing Pipe in K D Singh Babu Satdium | | | | | | | |
| ETP 1 *(Refer Drawing 3/3 )* | | | | | | | |
| Node Number | | Dia. mm | Material | length | Unit | Rates | Amount |
| J63 | J631 | 90 mm | H/PN 6 | 28.10 | m | 229.50 | 6,448.95 |
| J631 | J6311 | 75 mm | H/PN 6 | 10.00 | m | 169.20 | 1,692.00 |
| J631 | J6312 | 75 mm | H/PN 6 | 10.00 | m | 169.20 | 1,692.00 |
| J61 | J611 | 90 mm | H/PN 6 | 38.51 | m | 229.50 | 8,838.05 |
| J7431 | K1 | 90 mm | H/PN 6 | 14.16 | m | 229.50 | 3,249.72 |
| K1 | K8 | 90 mm | H/PN 6 | 70.00 | m | 229.50 | 16,065.00 |
| K1 | K82 | 75 mm | H/PN 6 | 1,027.24 | m | 169.20 | 1,73,809.01 |
| Total (P) | | | | 1,198.01 | m | | 2,11,794.72 |
| | | | | | | | |
| ETP 2 *(Refer Drawing 3/3 )* | | | | | | | |
| Node Number | | Dia. mm | Material | length | Unit | Rates | Amount |
| N23 | N231 | 90 | H/PN 6 | 40.27 | m | 229.50 | 9,241.97 |
| N22 | N221 | 90 | H/PN 6 | 40.00 | m | 229.50 | 9,180.00 |
| N21 | N211 | 90 | H/PN 6 | 21.04 | m | 229.50 | 4,828.68 |
| N8 | N81 | 90 | H/PN 6 | 12.50 | m | 229.50 | 2,868.75 |
| N10 | N101 | 90 | H/PN 6 | 11.66 | m | 229.50 | 2,675.97 |
| N7 | L1 | 90 | H/PN 6 | 46.30 | m | 229.50 | 10,625.85 |
| L1 | L9 | 90 | H/PN 6 | 80.00 | m | 229.50 | 18,360.00 |
| L1 | L92 | 75 | H/PN 6 | 1,197.83 | m | 169.20 | 2,02,672.84 |
| Total (Q) | | | | 1,449.60 | m | | 2,60,454.05 |
| | | | | | | | |
| Final Length & Cost of Distribution Network C - P - Q | | | | 2,197.65 | m | | 6,65,962.19 |

**Say 6.66 Lacs.**

❖ **Valve Table**

- As per design sluice valves have been provided at the outlet of each ETP. Air valve of required size has been provided at required regular intervals in main distribution line from ETP to sports facilities.
- And the rates of various valves are taken from the Jal Jeevan Mission project under State Water and Sanitation Mission.

**Table 3.12** Valve Abstract

| Valve Type | Valve Size (mm) | Quantity | Rates | Amount |
|---|---|---|---|---|
| Sluice Valve | 300 mm | 0 | 64,042.00 | 0 |
| | 250 mm | 0 | 48,109.00 | 0 |
| | 200 mm | 0 | 27,304.00 | 0 |
| | 150 mm | 0 | 17,626.00 | 0 |
| | 125 mm | 0 | 14,505.00 | 0 |
| | 100 mm | 4 | 14,455.00 | 57,820.00 |
| | 80 mm | 2 | 12,401.00 | 24,802.00 |
| Air Valve / Pressure Release Valve | 150 mm | 0 | 1,24,575.00 | 0 |
| | 100 mm | 6 | 80,025.00 | 4,80,150.00 |
| | 80 mm | 0 | 54,219.00 | 0 |
| Scour Valve | 250 mm | 0 | 48,109.48 | 0 |
| | 200 mm | 0 | 27,304.03 | 0 |
| | 150 mm | 0 | 17,625.57 | 0 |
| | 100 mm | 4 | 12,535.28 | 50,141.12 |
| | 80 mm | 0 | 10,160.84 | 0 |
| Total | 6,12,913.12 6.13 Lacs. | | | |

❖ **Analysis of Pump Motor for EPT 1 & ETP 2**

**Table 3.13** Capacity of Motor Pump

| For ETP 1 | | | For ETP 2 | | |
|---|---|---|---|---|---|
| Per Day Demand of ETP | 100 | KLD | Per Day Demand of ETP | 300 | KLD |
| Pumping Hrs. | 8 | Hr | Pumping Hrs. | 8 | Hr |
| Discharge in LPM | 208.33 | LPM | Discharge in LPM | 625.00 | LPM |
| PUMP MOTOR CAPACITY | | | PUMP MOTOR CAPACITY | | |
| Discharge in LPM | 208.33 | LPM | Discharge in LPM | 625.00 | LPM |
| Efficiency | 60% | | Efficiency | 60% | |
| Head | 17.31 | m | Head | 75.51 | m |
| Motor Capacity | 1.34 | HP | Motor Capacity | 17.48 | HP |
| Say | 2 | HP | Say | 20 | HP |

**Cost Analysis of Pump Motor & Power Consumption Charges**

- Rates of pump motors are taken from the Jal Jeevan Mission project under State Water and Sanitation Mission as shown in table no. 3.14, refer Annexure 1.

**Table 3.14** Cost of Motor Pump

| Item Description | Rate | Qty. | Unit | Amount |
|---|---|---|---|---|
| 2 HP | 35,843.14 | 2 | Job | 71,686.28 |
| 10 HP | 2,30,200.00 | 0 | Job | 0 |
| 20 HP | 2,95,145.00 | 2 | Job | 5,90,290.00 |
| 25 HP | 3,34,043.48 | 0 | Job | 0 |
| Total Cost of Pumps complete in all aspect including installation & labour charges. | | | | 6,61,976.28.00 Or 6.62 L |

- Total Cost of Pumps complete in all aspect including installation & labour charges is **6.62 L.**
- Power consumption of motor is calculated by considering present rate of electricity tariff of UPPCL, as shown in table no. 3.15.

**Table 3.15 per** Month Electricity Bill Charge

| ETP 1 Motor Operation Cost | | | ETP 2 Motor Operation Cost | | |
|---|---|---|---|---|---|
| Monthly Power Consumption of 2 HP motor | | | Monthly Power Consumption of 20 HP motor | | |
| Motor Capacity | 2.00 | HP | Motor Capacity | 20.00 | HP |
| Motor Capacity | 1.49 | kW | Motor Capacity | 14.90 | kW |
| Pumping Hrs. | 8.00 | Hrs. | Pumping Hrs. | 8.00 | Hrs. |
| Per Unit Bill | 7.50 | Rs. | Per Unit Bill | 7.50 | Rs. |
| Monthly Charge | 2,682.00 | Rs. | Monthly Charge | 26,820.00 | Rs. |
| 2 Motors of 2 HP | 5,364.00 | Rs. | 2 Motors of 20 HP | 53,640.00 | Rs. |
| Annual Cost | 64,368.00 | Rs. | Annual Cost | 6,43,680.00 | Rs. |
| **Expected Cost in next 5 years** | **3,21,840.00** | **Rs.** | **Expected Cost in next 5 years** | **32,18,400.00** | **Rs.** |

**3.5.3 Summary of Dual Water Supply System Including Assembling & Cost Analysis.**

| S.No. | Dual Water Supply System Components | Over All Cost (Lacs.) |
|---|---|---|
| 1. | ETP (Effluent Treatment Plant) installation cost | 39.99 |
| 2. | Distribution Network of HDPE PN-6 (75 mm to 110 mm dia.) | 6.66 |
| 3. | Installation of Valves in distribution | 6.13 |
| 4. | Installation of motors for pumping | 6.62 |
| | **Total Cost for Dual Water Supply System** | **59.40 L** |
| 1. | Operation Cost of ETP by motors of 2 Hp & 20 Hp for next 5 years for 16 hrs. | 35,40,240.00 Or 35.40 L |

**3.5.4 Cost Analysis of Water Recharge Mechanism**

- In **Uttar Pradesh**, **Jal Jeevan Mission** is going on under the **Ministry of Jal Shakti**. The aim of thismission is to provide fresh water to each and every household of villages by any surface source of water or any ground water source.
- 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.
- The executing body **State Water & Sanitation Mission** with collaboration of **Uttar Pradesh Jal Nigam**

Industrial Engineering Journal
ISSN: 0970-2555
Volume: 52, Issue 7, No. 1, July: 2023

**Grameen** & **Minor Irrigation** has finalized the rate of water recharge mechanism. Some schedule of rates of 5 divisions are as follows –

**Table 3.16** Rates of Water Recharge Mechanism

| S.No. | Division | Item Description | Rates | Unit | Amount |
|---|---|---|---|---|---|
| **1.** | Lucknow | Water recharge mechanism with in water work campus | 89,285.71 | Sqm. | 89,285.71 |

- Water recharge mechanism in KD Singh Babu Stadium thenwill cost**14.29 L**

**Table 3.17** Cost Analysis of Water Recharge Mechanism

| 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** |

- The design drawing of water recharge mechanism is approved by Technical Cell of State Water & Sanitation Mission, and can be proposed to KD Singh Babu Stadium for water recharge, refer Annexure 2.

### 3.6 Flow Chart of Dual Water Supply System

- The main working principle of dual water supply system is to conserve the fresh water as shown in fig.3.3.


**Fig. 3.3** Flow Chart of Water Supply System

Industrial Engineering Journal
ISSN: 0970-2555
Volume: 52, Issue 7, No. 1, July: 2023

### 3.7 Cost Analysis & Comparison

| Before Installation of ETP Pumping Required | | | | | |
|---|---|---|---|---|---|
| Pump 1 (2.5 Hp) (40.94 KLD) 8 hr. | | | Pump 2 (10 HP) (286.15 KLD) 8 hr. | | |
| Existing Annual Power Consumption of 2 HP motor | | | Existing Annual Power Consumption of 10 HP motor | | |
| Motor Capacity | 2.50 | HP | Motor Capacity | 10.00 | HP |
| Motor Capacity | 1.86 | kW | Motor Capacity | 7.45 | kW |
| Pumping Hrs. | 8.00 | Hrs. | Pumping Hrs. | 8.00 | Hrs. |
| Per Unit Bill | 7.50 | Rs. | Per Unit Bill | 7.50 | Rs. |
| Monthly Charge | 3,352.50 | Rs. | Monthly Charge | 13,410.00 | Rs. |
| Annual Charge | **40,230.00** | **Rs.** | Annual Charge | **1,60,920.00** | **Rs.** |
| Last 5 Yr. Charge (2017 - 2022) | **2,01,150.00** | **Rs.** | Last 5 Yr. Charge (2017 - 2022) | **8,04,600.00** | **Rs.** |
| | | | **Total Charge in last 5 yrs.** | **10,05,750.00** | **Rs.** |
| **After Installation of ETP Actual Pumping Required** | | | | | |
| **Pump 1 (2.5 Hp)** | | | **Pump 2 (10 HP) (75.42 KLD) 2.11 hr.** | | |
| **Existing Annual Power Consumption of 2.5 HP motor** | | | **Existing Annual Power Consumption of 10 HP motor** | | |
| There will be No pumping required as demand is reduced from 327.09 KLD to 75.42 KLD. Second pump house will fulfil the demand of 75.42 KLD. | | | Motor Capacity | 10.00 | HP |
| | | | Motor Capacity | 7.45 | kW |
| | | | Pumping Hrs. | 2.11 | Hrs. |
| | | | Per Unit Bill | 7.50 | Rs. |
| | | | Monthly Charge | 3,534.45 | Rs. |
| | | | Annual Charge | **42,413.37** | **Rs.** |
| | | | Next 5 yr. Charge | **2,12,066.86** | **Rs.** |
| **After Installation of ETP Actual Pumping Required (Using Solar)** | | | | | |
| **Pump 1 (2.5 Hp)** | | | **Pump 2 ( 10 HP) (75.42 KLD) 2.11 hr.** | | |
| **Existing Annual Power Consumption of 2.5 HP motor** | | | **Existing Annual Power Consumption of 10 HP motor** | | |
| There will be No pumping required as demand is reduced from 327.09 KLD to 75.42 KLD . Second pump house will fulfill the demand of 75.42 KLD. | | | Motor Capacity | 10.00 | HI |
| | | | Motor Capacity | 7.45 | kW |
| | | | Pumping Hrs. | 2.11 | Hrs |
| | | | Solar Cost per KW | 86,800.00 | |
| | | | Solar Cost per 7.5 KW | 6,51,000.00 | |
| | | | Monthly Charge | 2,170.00 | Rs |
| | | | Annual Charge | **26,040.00** | **Rs** |
| | | | Next 5 yr. Charge | **1,30,200.00** | **Rs** |

**Table 3.18** Comparison of Pumping Hours & Cost

- From the table no. 3.26, we observe that pumping hours of submersible pumps reduced from **16** to **2.11 hrs.**
- Similarly, the operation cost of submersible pumps has also reduced form **10.06 L** to **2.12 L** by assuming theUPPCL tariff charge constant for next 5 years.
- As the pumping hours is reduced the serviceability & durability of submersible will also increase.

### 3.8 RESULT & DISCUSSION

- This case study shows that every year **93.26 ML** or **255.50 KLD** can be saved by using proposing dual watersupply system in K D Singh Babu Stadium. Following results are found listed in table no. 3.19.

**Table 3.19** Results of Case Study

| S.No. | Parameters Analyzed | Results |
|---|---|---|
| **1.** | Water Demand in Stadium | 327.09 KLD |
| **2.** | Distribution Network in Stadium | 4.65 km |
| **3.** | Design Discharge of pumps (P1 & P2) | 40.94 KLD & 286.15 KLD |
| **4.** | Capacity of Submersible pumps | 2.5 HP & 10 HP |
| **5.** | Distance between pumps | 143 m |
| **6.** | Quantity of Waste Water | 255.50 KLD |
| **7.** | Operation Cost of last 5 yrs. | **10.06 L** |
| | **After Proposed ETP** | |
| **1.** | Proposed Network of ETP 1 & ETP 2 | 4.85 km inclusive of old length. |
| **2.** | Demand for ETP | 255.50 KLD |
| **3.** | Design Demand & Capacity of ETP 1 | 40.94 KLD & 100 KLD |
| **4.** | Design Demand & Capacity of ETP 2 | 286.15 KLD & 300 KLD |
| **5.** | Installation Cost of ETP | **39.99 L** |
| **6.** | Operation Cost for next 5yrs. | **35.40 L** |
| **7.** | Pumping Cost Submersible Pumps @ 2.11 hrs. | **2.12 L** |

### 3.9 CONCLUSIONS

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

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

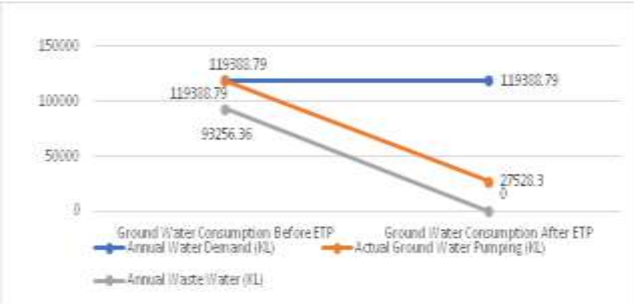



**Fig. 3.4** Comparison of Waste Water

### 3.10 FUTURE SCOPE

- This Study can be formed in all sports complex, commercial buildings etc. and dual water supply system iseffective technique to conserve the water.
- Area which uses high ground water can be studied with proposal of WTP.
- Cost of pumping can be studied by using non-conventional source of energy like solar energy.

### REFRENCES

[1] Ewa Burszta-Adamiak a & Paweł Spychalski (2021) “Water savings and reduction of costs through the useof 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 usingrooftop 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 andgroundwater at arsenic contaminated area in Vietnam”

[5] David J., Jia Liu (2014) “Optimizing rainwater harvesting systems for the dual purposes of water supplyand 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 distributionsystem”

[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 watersupply 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 ofindustrial water supply networks when using water resources with varying salinity”

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