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.

I. 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.

A. 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

➤ *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.
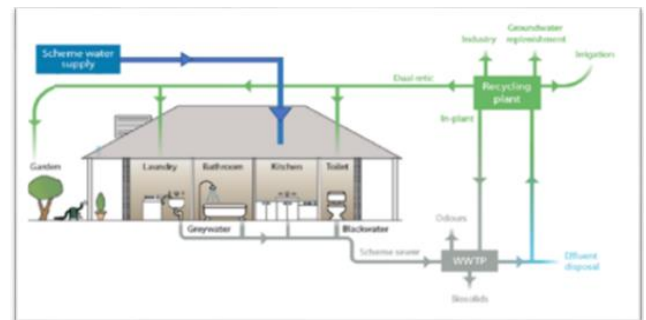

Fig. 1 Dual Water Supply System

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.

➤ *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.

B. Types of Dual Water Supply System
The dual supply might be termed **"potable"** supply and **"non-potable"** supply. Dual water distribution systems uses typical drinking water and high quality 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.**
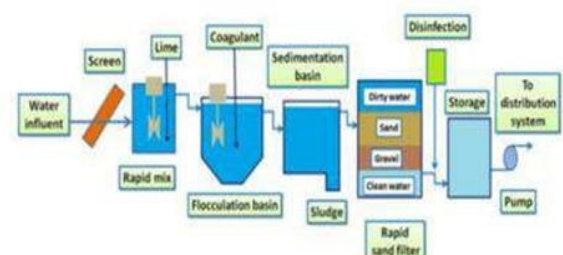

Fig 2 Potable Water Treatment Process

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 3 Non-Potable Water Treatment Process

C. 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 of irrigation 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.

D. Cost of Dwss

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

E. Suitability of Dwss

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

F. Advantages &Disadvantages of Dwss

➢ *Advantages*

- 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.

➢ *Disadvantages*

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

G. 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 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.

H. Introduction to ETP

ETP (Effluent Treatment Plant) is a process design for treating theindustrial waste water for its reuse or safe disposal to theenvironment as shown in fig.5.

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

Fig 5 ETP Flow Chart

II. LITERATURE REVIEW

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

A. General

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 a sports facility, including the collection and use of rainwater for non-potable purposes, was evaluated on the basis of technical, quantitative and financial data.

B. Literature Review

➢ 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)

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

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

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

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

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

• 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)

• 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)

• 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)

• DUAL WATER DISTRIBUTION SYSTEMS IN CHINA by Chunping Yang, Zhiqiang Shen, Hong Chen, Guangming Zeng (2007)

C. Problem Statement

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

D. Objectives

The Main Objectives of This Study are as Follows:

➢ To analyze the present water supply status.

➢ To estimate the cost of dual water supply system.

➢ To estimate the water saving & cost analysis.

➢ Propose the additional water recharge mechanism.

III. RESEARCH & 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.

❖ Selecting Site Location of Sport Facility.

Fig 6 Google Image of K D Singh Babu Stadium

❖ 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 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

❖ Data Collection

A. Annual Ground Water Consumption by K D Singh Babu Stadium 2017

Table 2 Water Consumed in Year of 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

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

Table 3 Water Consumed in Year of 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	
	Total Water Consumed in 2018								
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

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

Table 4 Water Consumed in Year of 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	
	Total Water Consumed in 2019								
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

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

Table 5 Water Consumed in Year of 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

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

Table 6 Water Consumed in Year of 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

❖ *Analysis of Annual Water Consumption.*

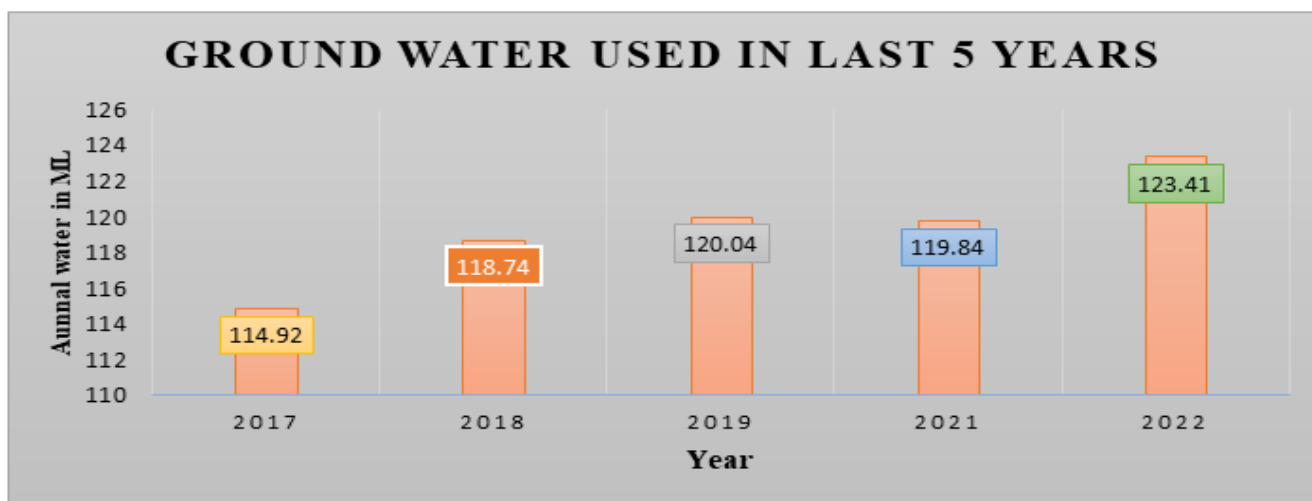- In last 5 years **114.92 ML, 118.74 ML, 120.04 ML, 119.84 ML & 123.41 ML** water is consumed shown infig.7.

Fig 7 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 7.

Table **7** Average of 5 Year Water Consumption

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	221.06	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	272.68	13.75	0.69	258.19	-	258.19	14.44
22	Public Water Tank	311.43	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	655.17	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

❖ *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 using dual 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 House 2**) 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.

A. 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.

B. 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.

➢ 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. 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.10.

Table 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 fordesign 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.

➢ 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 treatedwater.
- 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. 9 –

Table 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 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 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

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**

❖ *Valve Table*

- As per design sluice valves have been provided at the outlet of each ETP. Air valve of required size has beenprovided 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 andSanitation Mission.

Table 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 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 SanitationMission as shown in table no.14, refer Annexure 1.

Table 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 includinginstallation & 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, asshown in table no.15.

Table 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 Costin next 5 years	**3,21,840.00**	**Rs.**	**xpected Cost innext 5 years**	**32,18,400.00**	**Rs.**

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

Table 16 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**

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

Table 17 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 18 Cost Analysis of Water Recharge Mechanism

S.No.	Item Description	Qty.	L	B	Area	Rate	Unit	Amount
1.	Water rechargemechanism 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 & SanitationMission, and can be proposed to KD Singh Babu Stadium for water recharge, refer Annexure 2.

❖ *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.
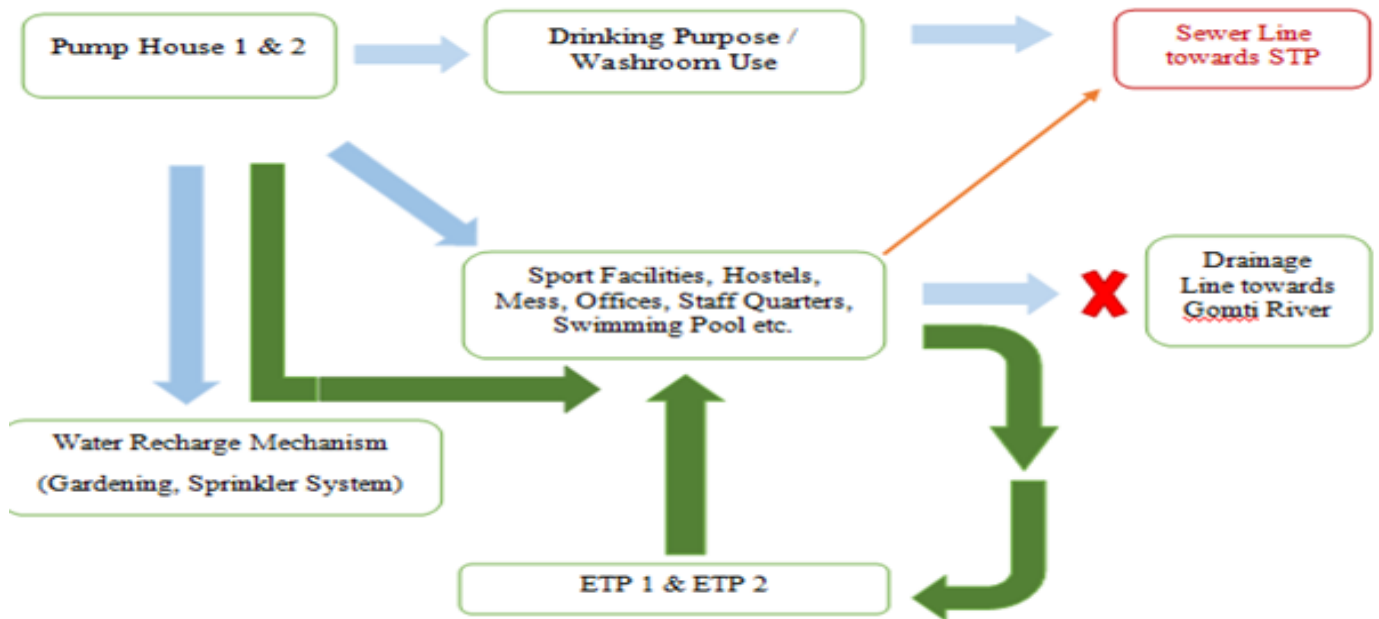
Fig 8 Flow Chart of Water Supply System

❖ *Cost Analysis & Comparison*

Table 19 Comparison of Pumping Hours & Cost

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 fulfil the demand of 75.42 KLD.			Motor Capacity	10.00	HP
			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

- 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 the UPPCL tariff charge constant for next 5 years.
- As the pumping hours is reduced the serviceability & durability of submersible will also increase.

IV. RESULT & DISCUSSION

- This case study shows that every year **93.26 ML** or **255.50 KLD** can be saved by using proposing dual water supply system in K D Singh Babu Stadium. Following results are found listed in table no.20

Table 20 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**

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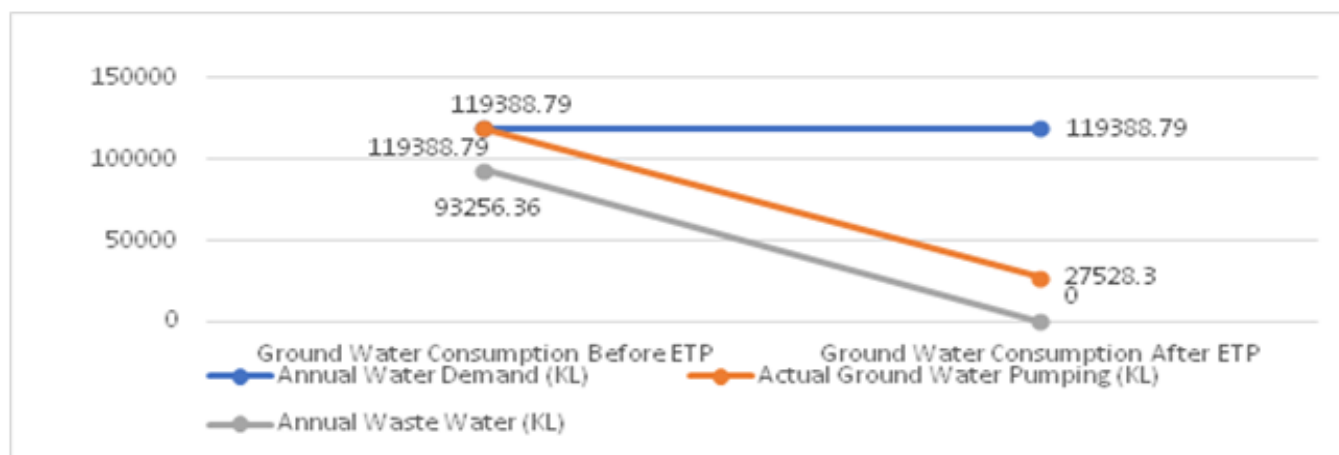- Per day we can save (251.68 KLD – 75.41 KLD = 176.27 KLD)

Fig 9 Comparison of Waste Water

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 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 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 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"

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