RECYCLING OF SEWAGE WATER FOR IRRIGATING GARDENS IN GANDHINAGAR TOWN A SUCCESS STORY IN URBAN WATER MANAGEMENT

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Abstract :

Gandhinagar is the capital of Gujarat which is located on banks of River Sabarmati. The town is well planned into 30 Sectors with ample area of green space and road side plantations. The town is having population of about 208,299 souls as per census of 2011. The water supply and sanitation of town is managed by Capital Project under the Road & Building Department of Govt. of Gujarat. The natural water sources in the part of the town are scare and are thus supplemented by drawl of 55 MLD from Narmada Main Canal from a distance of 11 Kms. The town has several consumptive and non-consumptive water requirements. As the town has ample amount of green area good amount of treated water is being consumed in irrigation requirement. The requirement of water to maintain the total area 140 Ha of parks and gardens is estimate to 11.2 MLD. The Road & Building (R&B) Department thus decided to setup the project for recycle sewage water for irrigating the Parks and Gardens in Gandhinagar Town. A raw sewage treatment project for recycling 10 ML water for irrigation of parks and garden is constructed and commissioned based on SBR technology in Gandhinagar.

1.0 INTRODUCTION

Gandhinagar, the capital of Gujarat State is located on the western bank of Sabarmati River and about 30 km away from Ahmedabad, which is the commercial and cultural heart of Gujarat. It is situated on 23^0 -13' North latitude and 72^0 - 41' East longitude. The topography of the town is almost even. The township has the river 'Sabarmati' passing on eastern side. Gandhinagar town, the capital of Gujarat State has been so planned that there is a balance between Govt. offices, private offices located at heart of the town while the residential are along the periphery of the town & gardens, parks, etc. evenly distributed over entire town. The town is planned in to 30 sectors which are of 1 km each in length and 0.8 km width having all required Infrastructure facilities. Gandhinagar is also known as "Green City". Gandhinagar has infocity near by, which is housing of IT companies. Many big IT companies like TCS, PCS, Sybase has presence in infocity.

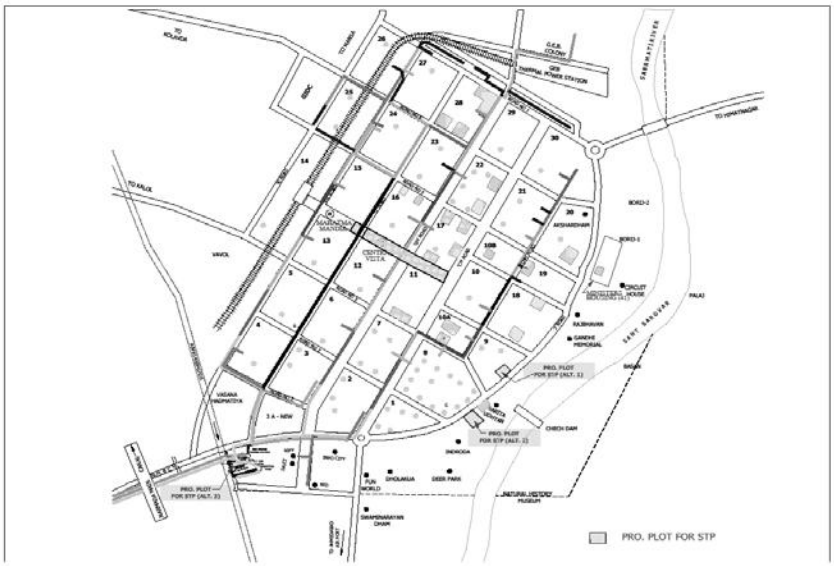

Figure-1: Map of Gandhinagar with location of sectors, roads, major Parks & Green areas

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Gandhinagar Town has a tropical climate. Aside from the monsoon season (June to October), the climate is fairly dry; Sabarmati River is not a perennial river & often dries up, leaving the town with low water levels. The rainfall in Gandhinagar Township is under the influence of South-West monsoon. There is an uneven distribution of the rainfall. Normally, average rainfall at Gandhinagar is 696[1] mm per year. Geologically the Gandhinagar city is covered with quaternary alluvium formation of Cambay basin. The alluvial formation is made up of multi layer Sand, Silt & Clay formation. According to the latest census data of the year 2011, Gandhinagar had a population of 208,299[2] persons. The ultimate population forecasted by Arithmetical Increment Method[3] comes out to be 350,000 by the year 2025.

2.0 EXISTING WATER SUPPLY SOURCES

Entire water supply and drainage schemes of Gandhinagar are looked after by Capital Project, Road & Building (R&B) Department. Earlier the water was supplied to Gandhinagar Township from Sabarmati River after treatment. As the Sabarmati is a non-perennial river in lean season the river remains dry. Total 68 nos. of tube-well were drilled from 1972-2000, with depths vary from 240 m to 300 m. In addition to above in year 1999 new R.C. well was constructed near Sarita Udhyan on river Sabarmati.With the passage of time, the quantity & quality of groundwater started deteriorating due to which the water became unreliable & inadequate for consumptive use of the town. As the water availability from Sabarmati River was reduced considerably due to lean flows, Gujarat Water Infrastructure Ltd, (G.W.I.L.) constructed water supply scheme based on Narmada Main Canal (N.M.C) and water is delivered at Charedi & Sarita Udhyan by laying 11 km long M.S. pipeline of 1200 mm dia. The pipeline is laid for water requirement of Gandhinagar Township & G.E.B. (Power House). The Filtration Plant of 30 MLD each at Charedi and at Sarita Udhyan is constructed. The filtered water is supplied to city through Dist. System of dia. 900 mm to dia. 80 mm C.I. pipeline. The U/G sump - 5 Nos. are used for the storage of filtered water. The RCC ESR of 45 lacs lit./45 m. height is constructed at Sarita Udhyan. Also, there are 12 nos. of public stand post.

At present, 55 MLD of filtered water is supplied to Gandhinagar Township through distribution network from water available through N.M.C.

3.0 WATER USAGES IN TOWN

As a Capital & administrative center of Gujarat, there are various Government & Education facilities like, Assembly, Secretariat & Directorate offices & various Boards & Corporations. There are also several Educational Institutions, Convention Center, Business offices, Industrial & commercial Area located in and around Gandhinagar. Due to this, there is a large floating population which comes to Gandhinagar. Thus over and above the residential population water needs for floating population is also to be satisfied. Gandhinagar is a well-planned town having well balanced town development plan with ample green area in each sector and wide roads with roadside and center medians which require large quantity of reliable water supply to maintain its flora. Also majority of the residential area, offices, institutes etc. require huge quantity of water for maintaining the green areas. Besides this, there is a nos. of gardens which cover almost 140 Ha. of area which are being maintained by department & require regular watering.

4.0 SEWAGERAGE SCHEME

At present, the sewage generation is about 40 MLD. The sewage is collected by existing underground drainage network at Main Pumping Station located at Sargasan on the southern side of

[1] Rainfall Statistics of India - 2015, India Meteorological Department (Ministry of Earth Sciences)
[2] Census of India-2011
[3] Manual on Sewerage & Sewage Treatment (Second Edition), CPHEEO

town. The sewage is then pumped through a rising main of about 14 km length to Jaspur Sewage Treatment Plant & treated up to the standards of surface water disposal.

5.0 NEED FOR PROJECT

The total area of gardens in Gandhinagar Town is 140 Ha & all are being maintained by the Director parks & gardens department. As the water demand for these gardens is huge, supplying treated water for these gardens proves to be very costlier due to the cost incurred to lifting, conveyance, treatment & distribution. Also town needs to gear up additional water supply for upcoming demand due to rapid development. Thus there arises a strong case for conserving the water resources by reusing the sewage for non-consumptive purpose particularly for parks & garden irrigation after suitable treatment.

5.1 WATER REQUIREMENT OF GARDENS

The gardens are grouped as under according to their water requirement:-

Group I	:	List of Gardens having water requirement more than 1 MLD
Group II	:	List of Gardens having water requirement between 0.5 to 1 MLD
Group III	:	List of Gardens having water requirement between 0.2 to 0.5 MLD
Group IV	:	List of Gardens having water requirement less than 0.2 MLD

As per IS 1172-1993 (Code of basic requirements for water supply & sanitation), the water demand for gardens is 80 KL/Ha/Day. Thus the total water requirement of gardens alone works out to be 11.18 MLD against the current supply of water around 55 MLD and sewage generation of 40 MLD. Hence, there is huge demand of water for maintaining gardens in Gandhinagar Town.

6.0 PROJECT DESCRIPTION

Looking to the total requirement of water for gardens of Gandhinagar, the Capital Project proposed to go for 10 MLD capacity of sewage treatment facility. During the course of feasibility studies, following three alternatives were suggested for reuse of sewage in the gardens:-

ALTERNATIVE I: Tertiary treatment of treated sewage from existing Jaspur STP & supplying treated sewage to various Gardens – Centralized treatment facility

ALTERNATIVE II: Treatment of Raw sewage (without treatment) by packaged sewage treatment plant of smaller capacity and supplying treated sewage to nearby Gardens – Decentralized treatment facility

ALTERNATIVE III: Treatment of Raw Sewage at Sargasan Pumping Station site & supplying the treated sewage to various gardens through pipeline – Centralized treatment facility.

6.1 ALTERNATIVE I:

Under this alternative, it was recommended to further treat a part of secondary treated sewage i.e. 10 MLD from existing STP at Jaspur by constructing tertiary treatment plant within the same premise based on “Filtration Process”. The treated sewage confirming to the standards of landscape irrigation proposed to be supplied either by laying pipeline or by tankers as per the requirement of individual group of gardens. The gardens having more water requirement proposed to be served by pipeline & those having lower water requirement proposed to be served by tankers.

For Alternative I, approximately 19 km pipeline is required to pump the treated sewage from tertiary treatment plant at Jaspur STP. Thereafter the treated sewage will be distributed to various gardens. Pipeline and pumping cost will be higher due to high head requirement. Also Narmada main canal, railway line, highway are required to be crossed for laying pipeline. O&M will be

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difficult due to high length and maintenance cost will also be higher. Thus the Alternative-I is not suitable from economical point of view.

6.2 ALTERNATIVE II:

Under this alternative, it was proposed to identify the gardens which fall in Group I & located near to each other so as to installed mini sewage treatment plants of smaller capacity such as 0.2 MLD, 0.5 MLD or 1 MLD. The raw sewage is to be supplied to mini STP from the existing sewage network. The treated sewage from package sewage treatment plant confirming to the landscape irrigation standards will be stored in underground sump & supplied to various gardens either by pipeline or by tankers. This alternative found suitable for setting up mini sewage treatment plants at different location but it involves complexity of maintaining individual STP & distribution of treated sewage to gardens. Also it requires parcel of land to be spared at different locations to set up mini STP in the existing gardens. Also due to fluctuating flow condition for continuous operation of mini STP was a cause of concern.

6.3 ALTERNATIVE III:

Under this alternative, it was proposed to install 10 MLD capacity STP by drawl of sewage from wet well at Sargasan Main pumping station & treat the sewage by setting up STP. The treated sewage will be collected in to the proposed Underground Sump; from there it will be pumped to an Elevated Storage Reservoir (ESR) for distribution of treated sewage to various gardens of Gandhinagar Township through proposed distribution network. As there is constraint about available space at Sargasan Pumping Station Site, suitability of various technologies for treating raw sewage at single point location were studied and compared with criteria like footprint area required, ease of O & M, treatment cost per MLD, capacity to take hydraulic as well as organic shock load, treated sewage quality (particularly BOD, COD, TSS, Nitrogen & Phosphorus) required for landscape irrigation, etc. The technology like “Sequential Batch Reactor” (SBR), seem to be the most suitable for the given site and also it seems to be the most effective & viable alternative.

7.0 Treatment of Sewage by Sequencing Batch Reactor (SBR) Technology

A sequencing Batch Reactor (SBR) is a fill and draw activated sludge treatment system. The unit processes involved in the SBR and conventional activated sludge systems are identical. Aeration and sedimentation / clarification are carried out in both systems. However, there is one important difference. In conventional plants, the processes are carried out simultaneously in separate tanks, whereas in SBR the processes are carried sequentially in the same tank. The complete biological operation is divided into cycles. Each cycle is of 3-6 hrs duration, during which all treatment steps takes place. A basic cycle steps comprises of Filling, Aeration, Settlement and Decanting. This is followed by Chlorination and Storage for purpose of recycle use.

A typical SBR cycle:

The complete biological operation is divided into cycles. Each cycle is of 3-6 hrs duration, during which all treatment steps takes place.

A basic cycle steps comprises of

- Fill,
- Aeration,
- Settlement and
- Decanting.

These phases in a sequence constitute a cycle, which is then repeated.

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Step 1: The raw waste water is filled in the basin up to a set operating water level. Aeration is done simultaneously for a predetermined time to aerate the effluent along with the biomass.

Step 2: After the aeration cycle, the biomass settles under perfect settling conditions.

Step 3: Once settled, the supernatant is removed from the top using the decanter. Solids are wasted from the tank during decanting phase.

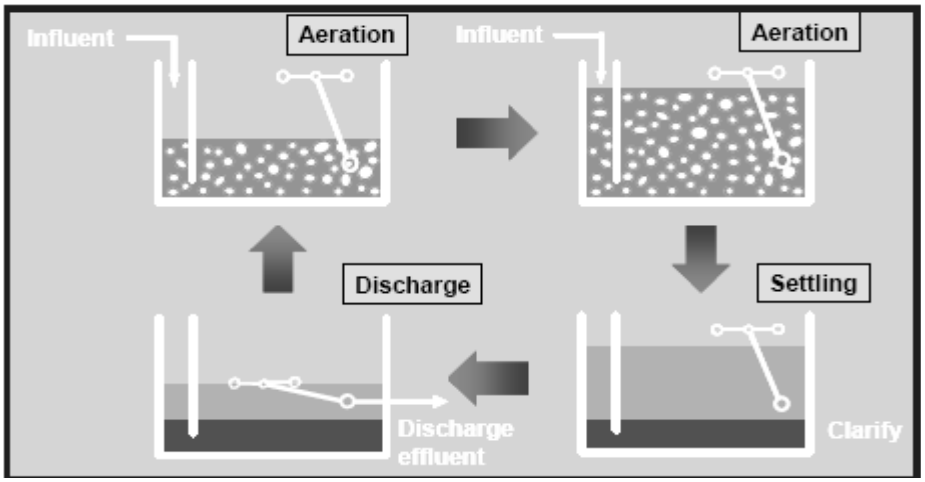

Figure-2: Typical SBR cycle

- **<u>SBR Basin:</u>**

Each SBR basin is divided by baffle walls into two sections (Zone 1: Selector, Zone 2: Main Aeration). For typical domestic wastewater treatment applications, these sections are in the approximate proportions of 10-15%, and 85% respectively. Sludge biomass is continuously recycled from Zone 2 to the Zone 1 selector using RAS (Return Activated Sludge) pumps to remove the readily degradable soluble substrate and favor the growth of the floc-forming microorganisms.

System design is such that the sludge return rate causes an approximate daily cycling of biomass in the main aeration zone through the selector zone. The mechanisms of Zone 1 and the internal sludge recycle eliminate the requirement for separate fill-ratio selectivity, anoxic, and anaerobic mixing periods. The selector is self-regulating for any load condition and operates under anoxic conditions during aerobic periods and anaerobic reaction conditions during non-aerated periods. Polishing denitrification and enzymatic transfer of available substrate during enhanced biological phosphorus removal is also achieved in the selector zone. The complete-mix nature of the main reactor provides flow and load balancing and a tolerance to shock or toxic loading, and the process prevents solids washout during peak or wet weather hydraulic surges.

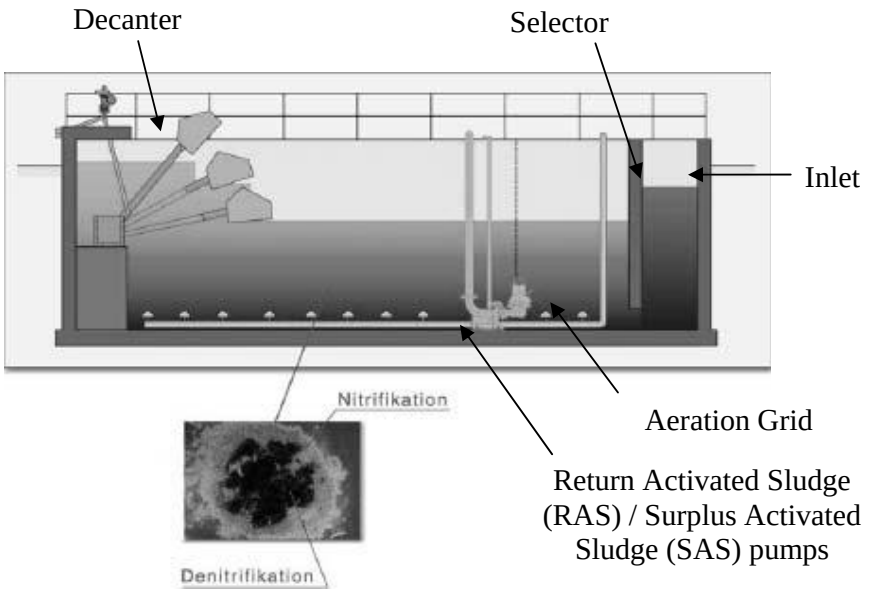

Figure-3:- Schematic drawing of SBR basin

- **Advantages and Disadvantages of SBR:**

Advantages of SBR over conventional process:

i. Process is simplified, final clarifiers and RAS (Return Activated Sludge) pumping are not required.
ii. Compact facility
iii. Operation is flexible, nutrient removal can be accomplished by operational changes.
iv. Can be operated as selector process to minimize sludge bulking potential.
v. Quiescent settling enhances solids separation (low effluent SS)
vi. Applicable for variety of plants.
vii. Proven effluent quality below 10 mg/l BOD_5 and TSS
viii. Proven nutrient removal quality below 1 mg/l Ammonia-N, 1 mg/l
ix. Nitrified effluent (no ammonia is present), doesn't consume further oxygen for nitrification and much beneficial for irrigation and fisheries.
x. Expansion potential; Simplified expansion- Each unit forms a modular treatment unit.
xi. Improved sludge settling: due to pre-react zone (biological selectors).
xii. Capability to equalize flows and loads therefore no need of equalization tank.
xiii. Low volume of sludge production. Lower Annual Operating Costs due to low volume sludge pumping, low waste sludge production, savings in precipitating chemicals (optimized biological phosphorous removal) and savings for cost of operating personnel and equipment.
xiv. Stabilized sludge production- no need of further anaerobic or aerobic digestion, sludge dewaters easily on drying beds.

Disadvantages:

i. Since the heart of the SBR system is the controls, automatic valves, and automatic switches, these systems may require more maintenance than a conventional activated sludge system. An increased level of sophistication usually equates to more items that can fail or require maintenance.
ii. Process control more complicated.

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Performance of SBR Technology

The performance of SBRs is typically better to conventional activated sludge systems. SBRs can achieve good BOD and nutrient removal.

Table:1 Characteristics of Raw & Treated Sewage considered for STP based on SBR Process:-

Parameter	Raw Sewage	Treated Sewage
BOD_5 (mg/l)	250	< 5
COD (mg/l)	400	<100
TSS (mg/l)	200	<10
TKN as N (mg/l)	45	<5
Total P (mg/l)	5	<1

Disinfection System - Chlorination

Chlorine is an inexpensive treatment option used to improve water's taste and clarity while knocking out microorganisms like bacteria and viruses.

Chlorine gas is released from a liquid chlorine cylinder by a pressure reducing and flow control valve operating at a pressure less than atmospheric. A basic system consists of a chlorine cylinder, a cylinder-mounted chlorine gas vacuum regulator, a chlorine gas injector, and a contact tank or pipe.

Centrifuge

Decanter centrifuge is a Sludge dewatering system for separation of Solid and Liquid phase.

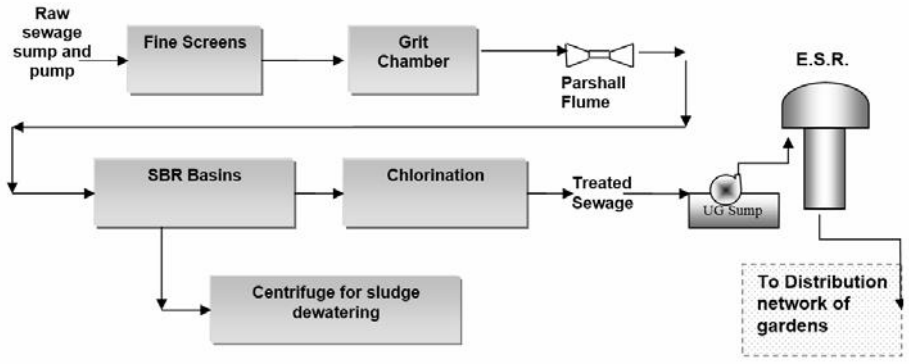

Figure - 4 : Flow Diagram of cyclic Activated sludge process / SBR base STP

Figure - 5 : Bird's Eye view of the Recycling STP Sargasan

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8.0 TENTATIVE COST OF THREE ALTERNATIVES

The preliminary cost of the various alternatives is as follows:-

Table: 2 Preliminary Cost of Three Alternatives

Alternative I		***Cost in million***
1	Treatment & Civil facilities	20.7
2	Conveyance and Distribution	123.92
	Total Cost in Million Rupees	***144.62***
Alternative II		
1	Treatment & Civil facilities	121.75
2	Conveyance and Distribution	52.70
	Total Cost in Million Rupees	***174.45***
Alternative III		
1	Treatment & Civil facilities	104.45
2	Conveyance and Distribution	50.00
	Total Cost in Million Rupees	***154.45***

Alternative II & III has advantage of surplus capacity creation of 10 MLD in the existing drainage & STP system.

(* Cost based on Schedule of Rate (SOR) 2008-09)

9.0 ADVANTAGES OF PROPOSED SEWAGE REUSE SCHEME:

The proposed sewage reuse scheme will have following advantages on it's implication.

1. Water used for Gardening from the Water supply project will be saved.
2. Cost of the water supplied from Narmada main canal after filtration and pumping to the ESR comes to Rs. 4.0/1000 lit, which will be saved by proposed reuse scheme.
3. The quantity of sewage coming at Sargasan pumping station and at Jaspur treatment plant will be reduced due to reuse of sewage for Gardening purpose.
4. Due to reduction of sewage flow, the consumption of electric power at Sargasan and Jaspur treatment plant will be reduced. The present cost of electric power for pumping of sewage is about 85 paisa / 1000 lit, which will be saved by proposed reuse scheme.
5. Total Rs. 4.85/m^3 will be saved against the M&R cost of the proposed reuse scheme which is averaging about Rs. 2.75 – 3.60 /m^3. Hence total direct benefit of about Rs.2.10 –1.25/m^3 will be achieved due to the proposed reuse scheme.
6. At present the problem of disposing the treated sewage is faced which can be reduced to some extent.
7. At present the gardens do not get the sufficient quantity of water as required. By the proposed sewage reuse scheme, the sufficient quantity of treated water will be available for Gardening purpose. This helps in achieving more development of Garden with better environment.

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10.0 Land Requirement for SBR Technology:

Land requirement for SBR process is very less as compared to the conventional process because of no primary and secondary settling tank, no return sludge pumping.

Table:3 Land requirement for various capacity SBR Plant:-

Sr. No.	Capacity of Plant MLD	No. of Basin	Area required (Ha)
1.	Up to 2	2	0.2
2.	2 to 3	2	0.25
3.	3 to 5	2	0.4
4.	5 to 10	2	0.7
5.	10 to 15	2	0.75

(Land requirement based on GWSSB Schedule of Rate 2014-15)

11.0 CONCLUSION:

Alternative I seem to be most cost effective, however considering generation of surplus capacity of 10 MLD being created in the existing drainage and STP plant due to full treatment and reuse of 10 MLD raw sewage. Alternative III seem to be most viable option. Further looking to the viability of the project & operational cost less than Rs. 3.0/KL, Alternative no. III with "Sequential Batch Reactor" (SBR) process was selected.

The project will offset both treated water supply and sewage treatment capacity by 10 MLD. Thus will save immediate investment required for treatment and distribution of 10 MLD drinking water and 10 MLD of sewage conveyance and treatment cost. Considering the overall water balance and use of the recycled water generated, the project is beneficial to the town.

12.0 PRESENT STATUS OF PROJECT

10 MLD capacity of STP based on SBR process is successfully Constructed and Commissioned at Sargasan Pumping Station Site. The parameters of water post treatment are being achieved as per design standards.

List of References:-

1. Census Report-2011
2. Manual on Sewerage & Sewage Treatment (Second Edition), CPHEEO
3. IS 1172-1993 (Code of basic requirements for water supply & sanitation)
4. Gujarat Water Supply & Sewerage Board (GWSSB) Gandhinagar, Schedule of Rates 2014-15
5. Feasibility Report for "Consultancy services for providing sewage water to gardens after treatment in various sectors of Gandhinagar township", 2008 by M/s. Multi Mantech International Pvt. Ltd., Ahmedabad
6. Detailed Projects Report for "Consultancy services for providing sewage water to gardens after treatment in various sectors of Gandhinagar township", 2011 by M/s. Multi Mantech International Pvt. Ltd., Ahmedabad

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