

Trouble Shooting in Water Treatment Process for Variable TDS

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Abstract:- This paper discusses how to tackle water treatment process with variable TDS. Concentration and high organic strength. The effects of TDS concentration changes when treating combined high TDS and high organic strength wastewater. The process design for a biological treatment system depends on the wastewater characteristics and equalization capacity for high TDS wastewater, biological performance depends on the proper adaptation of the biomass to changes in wastewater conditions. Adaptation potential can be enhanced by the introduction of halophilic microorganisms to the wastewater biomass. Another critical design consideration for TDS treatment is that concentrations are often subject to fluctuations, including variation in the rate of change. In wet season the TDS is higher, this could be attributed to higher turbidity during the wet season caused by the discharge of rain water into the Lekki Lagoon which brings debris, suspended particles and disturbance at the bottom. Total dissolved solid (TDS) and Total suspended solid (TSS) were both higher in the wet season than the dry season. When TDS is not maintained within acceptable limits, the operability of biological treatment systems can be adversely impacted by concentration fluctuation, such as that arising from upstream process changes. Some physicochemical parameters like temperature, transparency, dissolved solid, suspended materials, turbidity, conductivity, pH, total alkalinity, dissolved oxygen, nitrate, phosphate and salinity of water samples collected at Lekki Lagoon from May 2019 to April 2020 were evaluated, period of one year including dry season to wet season. Lekki lagoon, a large expanse of shallow freshwater experiences a typical tropical climate with the two seasons. The variation in physical and chemical parameters observed during the study period may be as a result of the influence of weather conditions.

Keywords:- Water Quality Parameters, Brackish, Spatial Fluctuation, Ichthyofauna, Lekki Lagoon. SBR, RO, DMF, Biological Treatments.

INTRODUCTION

“The Dangote group” has acquired the requisite industrial land in the Lekki Free Trade Zone, for setting up the Fertilizer Complex. To meet the water requirement of Fertilizer plant, there is a Raw Water Treatment Plant. The Dangote Fertilizer Project Site is located in Nigeria, Lagos State, and Lekki Free Trade Zone. The Lekki Lagoon is a large expanse of shallow fresh water located in both Lagos and Ogun state of Nigeria. This lagoon is considered to be a reservoir of relatively fresh water but TDS varies from high values in wet season to low value in dry season. The Dangote Group has ventured into the business of manufacturing and marketing of fertilizers. The Fertilizer complex consists of Ammonia and Urea plants with associated facilities and infrastructures 9 in the figure 2 & 3. The water requirement at normal capacity for the fertilizer project for various purposes is as follows:

- ▶ DM water (Flow rate: 120 m³/Hr. max.).
- ▶ CT make-up (Flow rate: 2140 m³/Hr. max.)
- ▶ Service water, Fire water & Potable water (Non-drinking) (100 m³/Hr.).
- ▶ Firefighting water.

The design total treated water flow requirement for fertilizer plant is minimum 2500 m³/hr.

The unit includes the following functional sections:

1. Dematerialized Water Production and Storage;
2. Condensate Polishing System.

The main objective of this Raw Water Treatment plant is to reduce the COD, BOD, suspended solids and dissolved Solids from Lagoon water. Permeate or product water shall be used for the feed water requirement of main Fertilizer plant by Dangote Fertilizer Ltd. As shown in the figure-4.

DESCRIPTION OF THE SITE AND PLANT LOCATION

The plant, located in Lekki free trade zone, Okunraye, Ibeju at Lagos state. State will be an excellent example of how to utilize a substantial amount of the country's significant gas resources, as a raw material in the Ammonia-Urea fertilizer process. As shown in the figure-1. Ultimately, the project, when completed will make the country self-sufficient in fertilizer production, thereby saving it the huge foreign reserves presently spent on importation of fertilizer. Dangote Group is one of the most diversified business conglomerates in Africa with a hard - earned reputation for excellent business practices and products' quality. Lekki Lagoon, located in Lagos and Ogun states of Nigeria covers an area of nearly 247 km² and lies between longitude 4°00'E and 4°15'E and latitude 6°22'N and 6°37'N. Lagos Lagoon links Lekki Lagoon at the upper part while Mahin creeks link the lagoon at the lower part. River Oni flows into Lekki Lagoon in the north eastern side while Rivers Oshun and Saga flow in from the north western parts. The lagoon is surrounded by many beaches.



Fig-1

- Dangote Fertilizer Project is the largest *Granulated Urea Fertilizer* complex coming up in the entire fertilizer industry history in the World, with an investment of 2.5 Billion USD capacity of 3 Mil TPA.
- Acquired 500 hectares of land for the Fertilizer Complex.
- Natural gas is the main raw material for the plant.
- Tata Consulting Engineers, India, is the Project Management Consultants (PMC) for the project.
- Current consumption of Urea is 700,000 tonnes. Very poor per hectare usage of fertiliser leading to very poor crop yield.
- By 2020, Nigerian Population - around 207 Million which would lead to increased food consumption.
- Estimates point out that around 5 million tonnes of Fertilisers are required per year in Nigeria in next 5-7 years bifurcated into 3.5 Mil tonnes of Urea and 1.5 Mil tonnes of NPK
- Current production levels are at 1.6 Mil tonnes

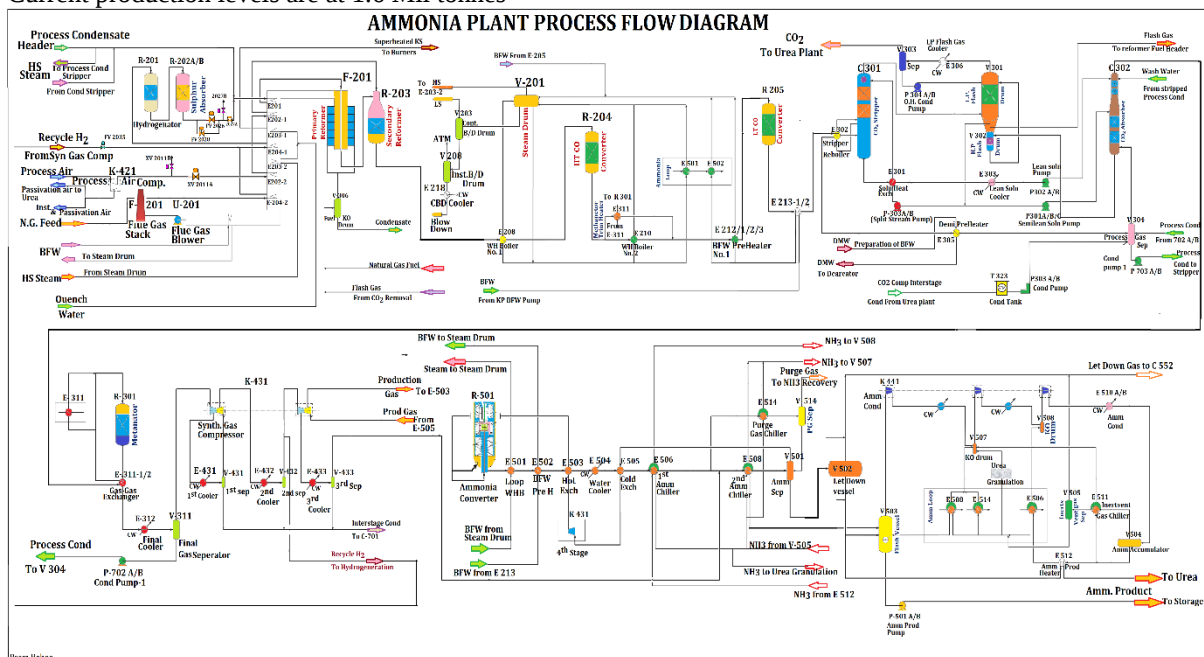


Fig-2

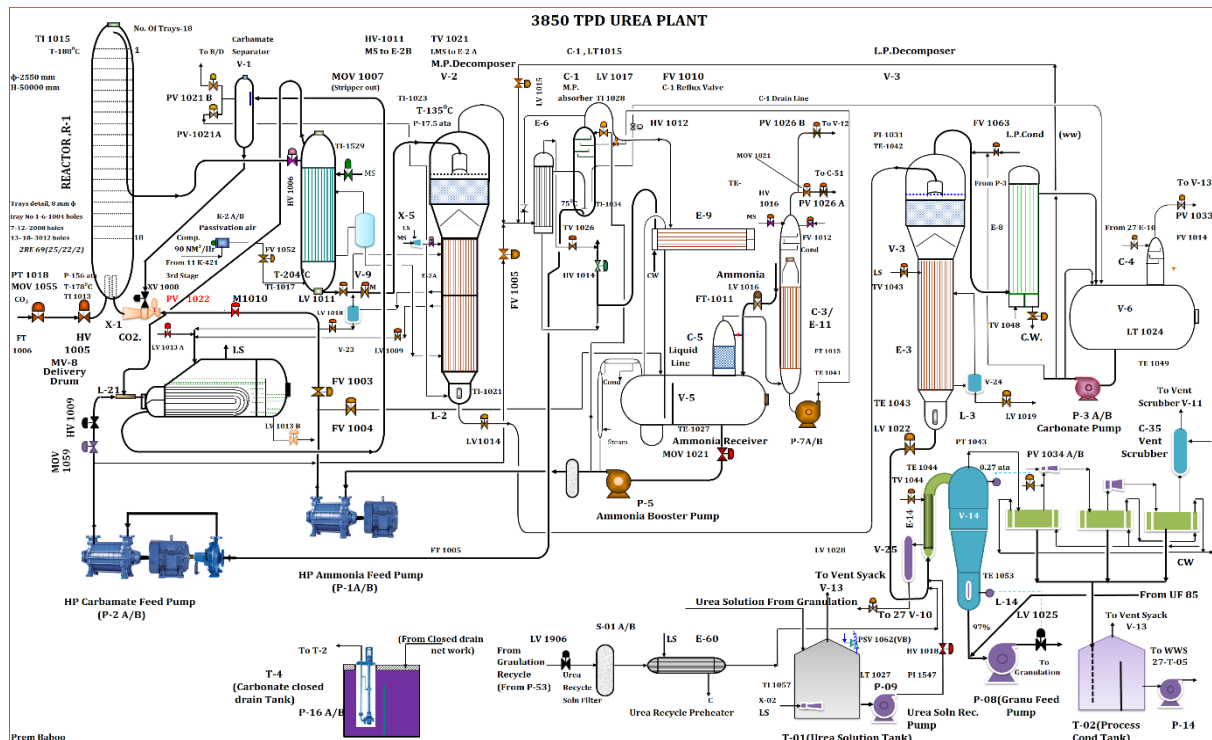


Fig-3

Process Description

The Raw Water Treatment Plant will comprise of the following:

1. Intake System from Lekki Lagoon
2. Biological Treatment System (SBR)
3. Dual Media Filters
4. Ultra filtration (UF) System
5. Reverse Osmosis system
6. Outfall piping & sub-sea diffuser piping for Reject disposal.

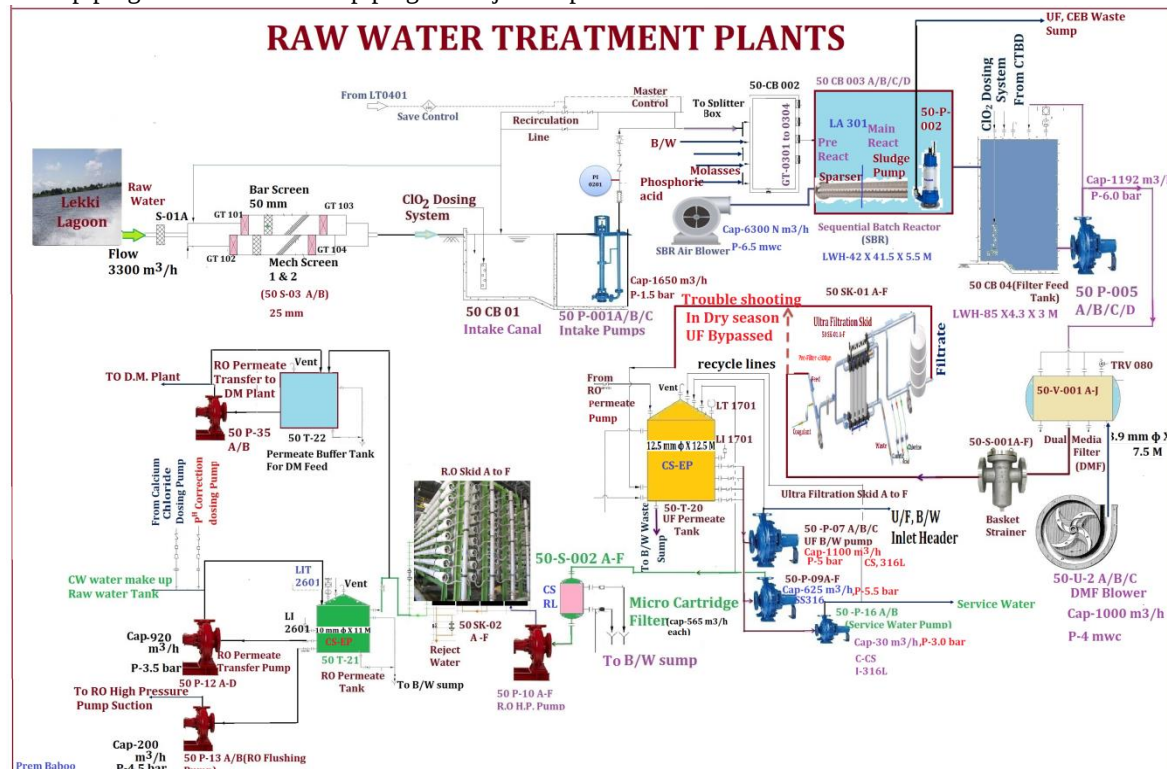


Fig- 4

INTAKE SYSTEM

The Intake taken from the lagoon by a canal. The maximum design flow of water is 3300 m³/hr considering total requirement of fertilizer plant. At the lagoon side near intake point, there is window bar type screen with a mesh size of 100 mm provided to prevent entry of biological mass like hyacinth. At the entry point of the Intake well, the canal is divided into two sections, each section designed for 50% of the total flow. Both sections of the canal are provided with 1 no. of 50 mm bar screen, followed by an Automatic Mechanical screen (25 mm). Isolation gates are provided at upstream of 50 mm manual screen & downstream of Automatic Mechanical Screen.

Mechanical bar/rake screens have been provided at the entrance to each canal to segregate the weeds and wastes. The depth of the lagoon is considered based on lagoon top level +1 meter and lagoon bottom level -1m and the average water depth of the lagoon is considered to be approx. 2 m at intake canal. The canal will empty into a forebay to convey the water into the sump of the pump house. Vertical Turbine pumps are installed in the pump house to ensure cavitations' free operation. Individual pump sump has been designed for each pump with sluice gate for isolation purpose. Chlorination provision of raw water given in canal before entering in to forebay. Only shock dosage provision is provided so as to avoid any biological growth inside the Intake well.

RAW WATER QUALITY FROM LEKKI LAGOON

Sr. No.	Description	Unit of Measurements	Minimum value	Maximum Value
1	pH		7	8
2	Electrical Conductivity @ 25°C	µS/cm	51	1492
3	Dissolved Oxygen	Mg/lit as Ion	1.98	4.67
4	Dissolved CO ₂	Mg/lit as Ion	3.64	4.5
5	Turbidity	NTU	3.47	50.4

Table- 1

The temperature variation at the site is from 20 °C to 36°C. The TDN also varies according to temperature, the TDN is the function of Temperature. Nitrogen solubility may differ between compounds. At 20°C, Nitrogen oxide solubility is 12 g/L, and nitrile acetate solubility is 640 g/L, whereas nitrogen chloride is water insoluble. Nitrates and ammonia dissolve in water readily. The bacterial Nitrogen also depends upon temperature. Ammonium, nitrate and nitrite play the most important role in biochemical processes, but some organic nitrogen compounds in water may also be of significance. Total nitrogen represents the sum of organic and inorganic nitrogen compounds. Different value of TDN always given in table at...°C, means temperature always mentioned. There is different type of Nitrogen in dissolved water. Depending on water properties, various inorganic nitrogen compounds may be found. In aerobic waters nitrogen is mainly present as N₂ and NO₃⁻, and depending on environmental conditions (Temperature/humidity etc.) it may also occur as N₂O, NH₃, NH₄⁺, HNO₂, NO₂⁻ or HNO₃.

For high TDS wastewater, biological performance depends on the proper adaptation of the biomass to changes in wastewater conditions. Adaptation potential can be enhanced by the introduction of halophilic microorganisms to the wastewater biomass. Another critical design consideration for TDS treatment is that concentrations are often subject to fluctuations, including variation in the rate of change. When TDS is not maintained within acceptable limits, the operability of biological treatment systems adversely impacted by concentration fluctuation, such as that arising from upstream process changes. To most effectively treat wastewaters, an acceptable level of influent TDS fluctuation must be defined. The proper determination of acceptable variability is critical to the design of a biological treatment system for high strength TDS and organic wastewaters to maintain the required operating efficiencies. The TDS concentration changes are to:

1. Defined from literature sources the observed response of biomass characteristics, such as the impact on bio kinetics, and the cited industry design margins for treatment systems; and
2. Present a case study that explores process design options for buffering variable TDS levels.
3. Stable performance of primary and biological treatment steps is essential for meeting effluent discharge limits and for optimizing performance of post treatment steps.
4. High TDS effluents have been traditionally treated by primary physical and chemical means.
5. Wastewaters characterized by elevated Total Dissolved Solids (TDS) levels and high organic content are produced by food, petroleum, and petrochemical facilities.
6. The high TDS effluents are treated by biological means to achieve carbon, nitrogen and phosphorous removal. The objectives of this discussion on.

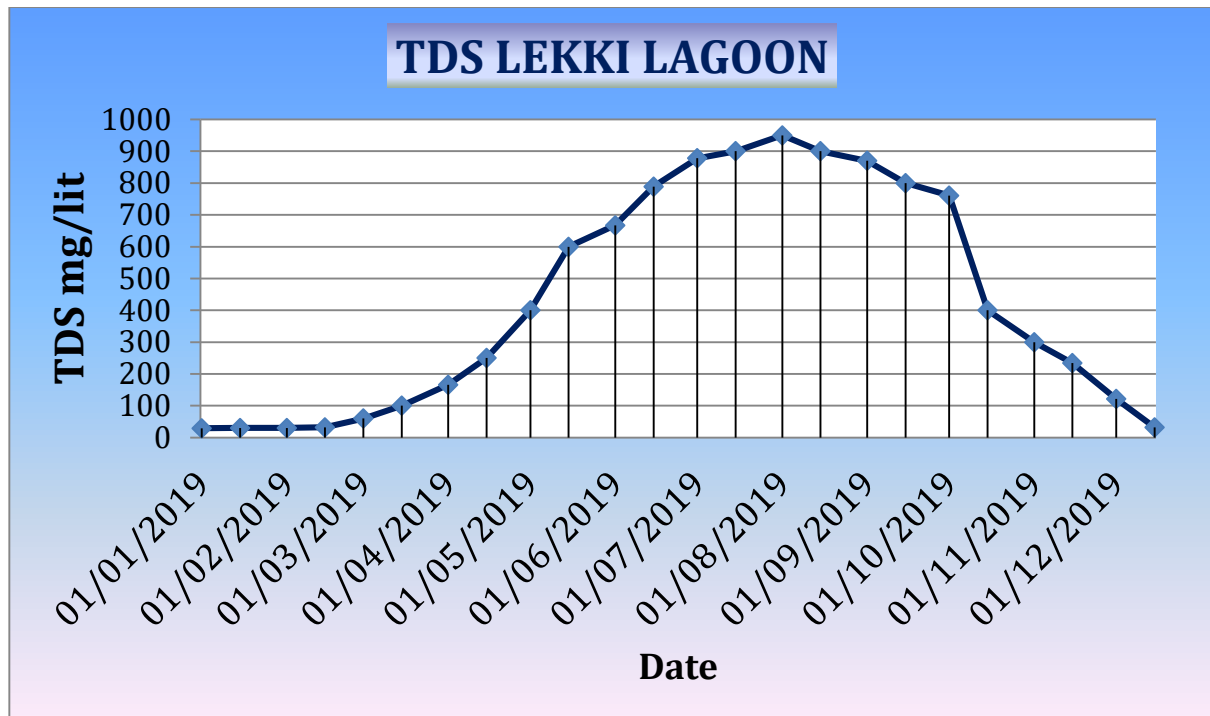


Fig-5

Detail analysis for wet season to dry season of Lekki Lagoon

Sr. No.	Description	Unit of Measurements	Minimum value January 2020	Maximum Value July 2019
1	TDS	Mg/lit as Ion	29.08	905
2	TSS	Mg/lit as Ion	2.67	24.8
3	Specific gravity		1.00	0.998
4	Total BOD ₅	Mg/lit as Ion	16	92
5	Total COD	Mg/lit as Ion	32	137.2
6	Dissolved BOD ₅	Mg/lit as Ion	0.4	40
7	Dissolved COD	Mg/lit as Ion	0.64	63.56
8	Hardness	Mg/lit as Ion	7.89	150.4
9	M. Alkalinity	Mg/lit as CaCO ₃	8.69	96.4
10	Oil & Grease	Mg/lit as CaCO ₃	0.32	8.12
11	Phosphate	Mg/lit as Ion	0.05	0.48
12	Sulphate	Mg/lit as Ion	0.75	62.68
13	Chloride	Mg/lit as Ion	8.61	437.2
14	Nitrite	Mg/lit as Ion	0.02	0.06
15	Nitrate	Mg/lit as Ion	0.02	0.53
16	Total Kjeldal Nitrogen	Mg/lit as Ion	32.23	48.34
17	Reactive Silica	Mg/lit as Ion	2.51	5.97
18	Total Silica	Mg/lit as Ion	3.15	6.14
19	Calcium	Mg/lit as Ion	0.79	8.81
20	Magnesium	Mg/lit as Ion	1.42	29.4
21	Sodium	Mg/lit as Ion	5.69	286.5
22	Potassium	Mg/lit as Ion	1.29	8.74
23	Iron as Fe ⁺⁺	Mg/lit as Ion	0.59	1.26
24	Zinc	Mg/lit as Ion	0.02	0.03
25	Total Chromium	Mg/lit as Ion	< 0.1	0.24
26	Chromium as Cr ⁺⁺⁺	Mg/lit as Ion	< 0.1	0.14
27	Chromium as Cr ⁺⁺⁺⁺	Mg/lit as Ion	< 0.1	0.1
28	Nickel	Mg/lit as Ion	0.05	0.07
29	Lead	Mg/lit as Ion	0.01	0.01
30	Fluoride	Mg/lit as Ion	0.08	0.14
31	Boron	Mg/lit as Ion	0.001	0.0041
32	Dissolved Boron	Mg/lit as Ion	0.3	1.27
33	Suspended Boron	Mg/lit as Ion	0.87	3.66
34	Total Organic dissolved Carbon	Mg/lit as Ion	0.1	21.18
35	Total organic suspended Carbon	Mg/lit as Ion	10.45	24.56
36	Algae Cell count	Cell Count	2.13	24

Table-2

RWTP DESIGN CRITERIA AND PLANT CAPACITY

Sr. No.	Description	Maximum Value
1	Total inlet flow	3027 m ³ /hr
2	Plant Design Capacity	3229 m ³ /hr
3	Overall plant	82.5%
(A) SEQUENTIAL BATCH REACTOR (SBR)		
1	Number of Unit	4 number
2	Design Flow Rate per SBR	810 m ³ /hr
(B) DUAL MEDIA FILTER (DMF)		
1	Number of Unit	10 Number
2	Design Feed Flow rate per DMF	391 m ³ /hr
(C) ULTRAFILTRATION SYSTEM (UF)		
1	Number of Unit	6 Number
2	Design Flow rate (UF Skid)	691 m ³ /hr
3	Average Feed Flow rate (UF Skid)	634 m ³ /hr
4	Recovery	92.2%
5	Gross Flux	72.6 LMH
6	UF permeate Flow / skid	485 m ³ /hr
(D) REVERSE OSMOSIS SYSTEM (RO)		
1	Number of Unit	6 Number
2	Design Flow Rate/RO skid (Feed Flow)	565 m ³ /hr
3	Recovery	85%
4	Flux	≤19 LMH
5	RO Permeate Flow per skid	480 m ³ /hr

Table-3

SEQUENTIAL BATCH REACTOR (SBR)

After Raw water pumping station, the water is distributed through splitter box to four SBR Basins. The basins receive influent during all phases of the cycle. Surplus activated sludge (SAS) is disposed directly from each basin. The raw water flows to the SBR basins via splitter box. As shown in the figure-9. The chamber splits the flow to each basin via manual gate/penstocks. The influent pipe passes into the pre-react chamber and terminates in a bell mouth mid-way along the pre-react chamber. Influent to the SBR basins is continuous during all stages of the cycle. Float switches in each basin detect a High-High level and having generate alarm; manual action to be taken by operator to stop the flow to that basin by closing



Fig-6



Fig -7

the gate/penstock. Suitable bypass arrangement is provided to bypass the feed raw water during lean season, as this is seasonal variation, full flow will be bypassed the SBR & sends to filter feed tank during lean period. A provision has been made to dose carbon source & phosphoric acid in Splitter Box. Air Blowers, Surplus Activated Sludge (SAS) Pumps, Decanter & Motorized Air Line Valves are automatically controlled by PLC. Treated water from SBR is send to Filter Feed Tank.

SBR PROCESS

A typical SBR process consists of the following time-based phases; it is designed with a normal cycle of 240 minutes or 4 hours. Each cycle has 120 minutes of react phase as aeration phase with DO control to achieve simultaneous nitrification and de-nitrification, the remaining time is made up of 60 minutes of settle phase, and 60 minutes of decant phase:

1. Aeration: Raw water from screening in the Canal flows into the basin. The basin is aerated while filling and biological oxidation takes place simultaneously.
2. Sedimentation: Aeration is stopped and the solids settle to the bottom of the basin leaving clear water on top. The basin continuously receives the influent.
3. Decantation: The clear water is discharged from the top of the basin, while the basin continuously receives the influent. Sludge shall be disposed to UF CEB waste sump during this phase. Influent is received continuously during all phases of the cycle, including sedimentation and decantation. The duration of each cycle and segment of each operating cycle are the same among all basins in a time-based system as shown in the figure -8.

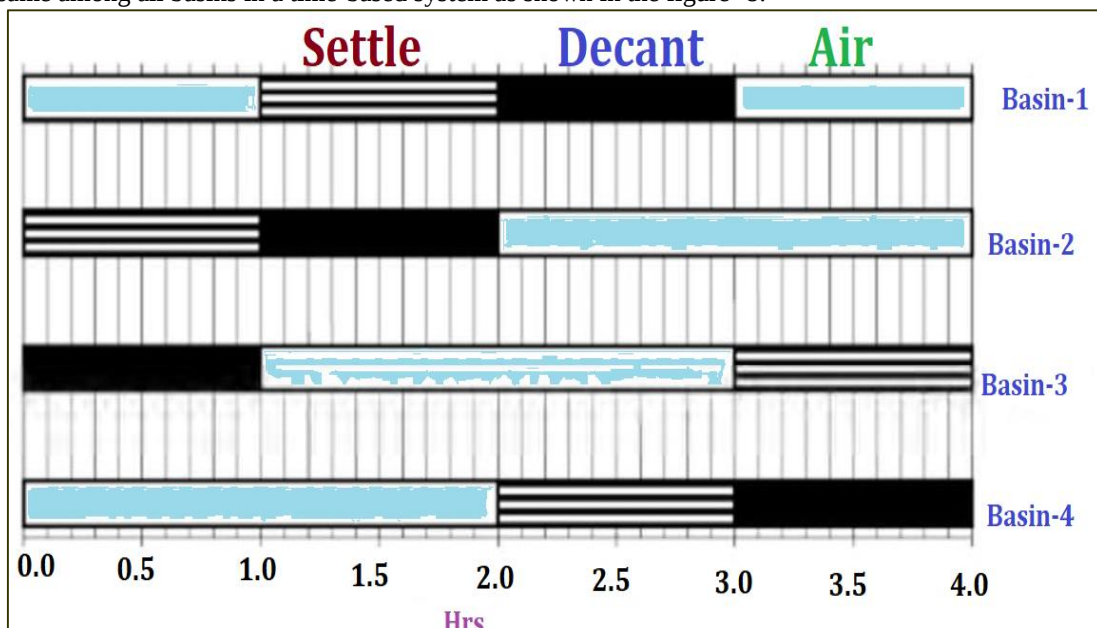


Fig-8

SBR BASIN

The SBR basin is divided into two zones, the pre-react zone and the main react zone. A baffle wall with openings at the bottom is constructed to divide the SBR basin into the two zones as shown in the figure-9. The raw water flows continuously into the pre-react zone and is directed down through orifice openings at the bottom of the baffle wall into the main react zone. The pre-react wall baffles the incoming flow and prevents short-circuiting. The volume of the pre react zone is typically 10 to 15 percent of the total basin volume. For the stabilization of SBR system, sludge recirculation line from SAS pump outlet to Inlet of SBR shall be provided.

1. **Pre-react zone-** The pre-react zone also provides pre-treatment of the wastewater before it enters the main react zone. Since influent flows continuously into the pre-react zone, a high concentration of soluble BOD is available to the microorganisms in a relatively small basin volume. This situation creates a high "Food to Microorganisms" (F: M) ratio. The high F:M ratio encourages the maximum bio-sorption of food by the microorganisms. The pre-react zone therefore acts as a biological selector encouraging the proliferation of the most desirable organisms.
2. **Buffer Zone-** The design volume of the basin is based on a combination of the volume required for the hydraulics based on the peak flow conditions and the volume occupied by the sludge. A "Buffer Zone" is included in the design as a safety factor to ensure the SBR process's ability to withstand the unusual flows and loadings. This zone is typically a minimum of three feet deep, extending from the top of sludge blanket to the BWL after decanting.
3. **Auto DO Control-** SBR use auto DO control for plant operation. There are two DO set points, one for first 90% of the react phase & another for balance 10% of the react phase. The DO for the last part of aeration is higher in order to encourage the growth of bacteria. For the first five minutes of the react phase the blower (VFD – starter) is run without DO control. During this period the blower runs at a speed of 50%. This is to ensure that the basin contents are thoroughly mixed and therefore that the DO reading is representative of the basin as a whole. After this period, the DO signal in SBR basin is controlled against the DO set point by the PLC. The PLC has a closed-loop control function that incrementally adjusts the speed of the blower in order to control the measured DO against the set point DO.

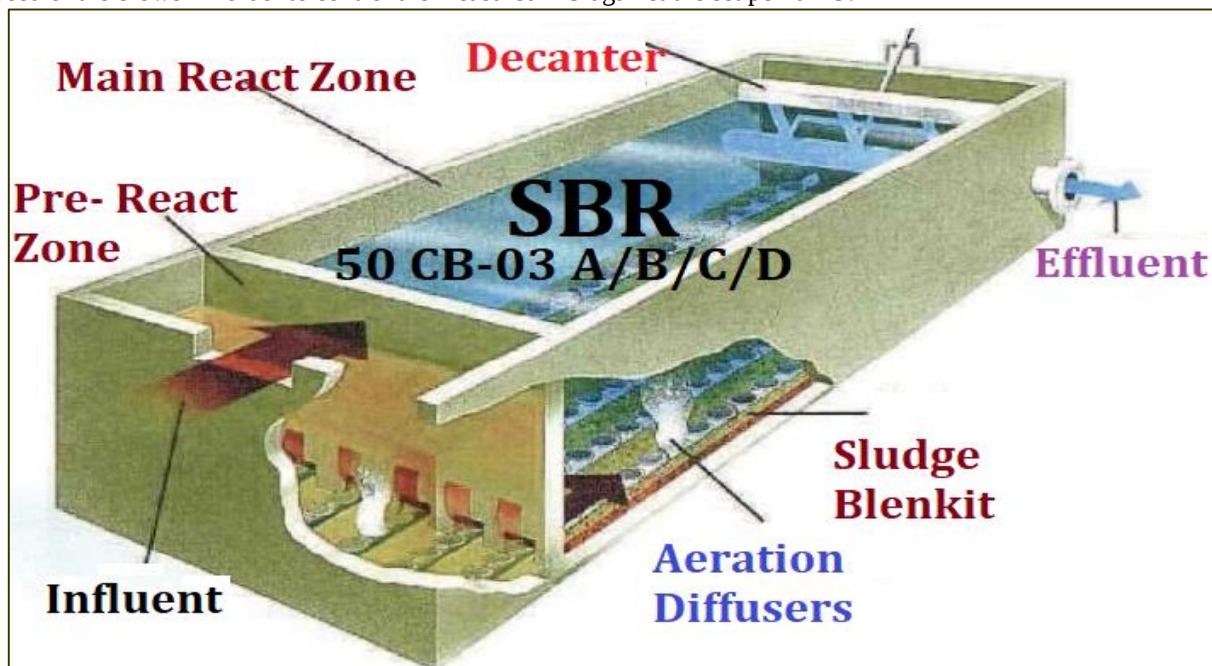


Fig-9

Electro-mechanical Decanter

There are twin decanters mounted in each basin. The decanters are mounted by way of a decanter wall plate seal and bearing ring assembly anchored onto the concrete wall. Each decanter utilizes a connecting rod to an actuator. Each actuator has a motor drive. Effluent flows from the decanters into an outlet pipe through the basin wall to the Filter Feed Tank. The Filter Feed tank is an integrated Tank to the SBR basin. The decanter is controlled on a timed basis. However, the limits of travel are ultimately controlled, as a fail-safe measure, by position limit switches on each of the decanter actuators.

SBR DOSING SYSTEM

CARBON SOURCE (MOLASSES) DOSING SYSTEM:

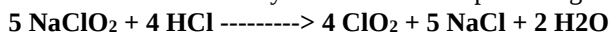
Carbon Source (Molasses) dosing is provided in Splitter Box before SBR due to variable levels of BOD in the lake water. Carbon Source (Molasses) dosing purpose is to provide food for Bacteria. Carbon Source (Molasses) Dosing system comprises of 2 numbers Dosing Pumps and 2 numbers of Dosing Tanks Carbon Source (Molasses) Bulk Storage tank along with unloading cum transfer pumps are also considered.

PHOSPHORIC ACID DOSING SYSTEM

Phosphoric Acid dosing is provided in Splitter Box before SBR due to variable levels of phosphorus in the lake water. Phosphoric Acid acts as a nutrient to Bacteria. Phosphoric Acid Dosing system comprises of 2 numbers. Dosing Pumps and 1 number of Dosing Tanks. Phosphoric Acid concentration is 40%, same concentration without dilution is considered for dosing in SBR. Based on the daily measurement of phosphorus in raw water phosphoric acid dosage & its frequency is decided.

CHLORINATION SYSTEM

ClO₂ dosing system provided for reduction of Organics and disinfection purpose. In RWTP, chlorine shock dosing at intake well & continuous dosage after Biological Treatment in Filter Feed Tank is considered. Chlorination provision is also given for the RO permeate stream going to the DM plant. The dosage for ClO₂ adjusted & fixed at site during commissioning. The generation reaction chamber stems are based on underwater concept which is the safest and most reliable technology for generation of ClO₂. The reaction chamber is designed in such a way that it is able to produce chlorine dioxide instantaneously in a controlled underwater environment. The chlorine dioxide system installed for producing ClO₂ as following equation-



COAGULANT DOSING SYSTEM:

Coagulant dosing (FeCl₃ – Ferric Chloride) is provided at DMF Feed Water. Coagulations ensured better removal of the suspended and colloidal particles to be removed and trapped in DMF & Ultra filtration system. The system comprises of 2 number Dosing Pumps and 2 numbers of Dosing Tanks FeCl₃ Bulk Storage tank along with unloading cum transfer pumps are also considered. Coagulation with FeCl₃ is effective in the pH range of 6 to 10, incoming raw water stream is at the pH of 6.5 to 8. One number of Static Mixer of size 900 OD is provided after the dosing point for mixing of coagulant with raw water, suitable contact time is provided in the static mixer so that effective suspended particle removal can happen. FeCl₃ concentration is 40%, same concentration without dilution is considered for dosing prior to Dual Media Filter. As per UF projections the FeCl₃ dosage provided & its frequency is continuous as per the TSS load.

DUAL MEDIA FILTER

The SBR treated water is stored in the Filter Feed Tank. The effluent still has some suspended solids therefore it is required to be passed through Dual Media Filters. The SBR effluent having TSS is pumped through 10 Numbers of Dual Media Filters by Filter feed pumps. Each DMF is sized for approximately 393 m³/hr capacity & each Filter feed pump size for 1192 m³/hr capacity. DMF further reduces suspended solids from the effluent. The filter is Horizontal cylindrical provided with Sand and Anthracite as filtrating media. Backwash of the filters is initiated either if the total daily flow achieved by the flow tantalizer at each DMF outlet or after a preset time interval of 24hrs. (Whichever condition occurs first). Backwash of the filter can also be initiated manually. Filtered Water is directly fed to Ultra Filtration Unit via Basket Strainers. A tapping is provided at the outlet header of DMF header for filling up of the DMF backwash tank. Backwash tank is sized to cater the water requirement for 2 DMF backwashes. Air scouring of the DMF is done to loosen the bed through 3 numbers air scouring blowers for DMF. The backwash of all Dual Media filters is done with 3 nos. DMF Backwash Pumps. During seasonal variation the SBR are bypassed & raw water is directly fed to filter feed tank & further to DMF. Due to higher TSS level in raw water it is suggested to backwash the filter twice a day (once after every 12 hrs).

RO INLET CHEMICAL DOSING SYSTEMS

ACID DOSING SYSTEM:

HCl dosing is a provision given to reduce the pH, in general the acid dosing is required. Scale control is done through Anti-scalant only. Dosing system is provided with 2 numbers of dosing tank and 2 numbers dosing pumps. The acid dosing is controlled through stroke controller & the dosing rate of the Acid is controlled from the pH analyzer provided at the outlet of cartridge filter. Hydrochloric Acid is available in liquid form; its commercial available concentration is 33%, same concentration without dilution is considered for dosing.

SMBS (SODIUM META BISULPHITE) DOSING SYSTEM:

SMBS to remove any residual chlorine in feed water as the same can damage the RO membranes. Sodium Meta bisulphite (SMBS) is the typical chlorine reducing agent of choice for larger RO systems. Dosing system is provided with 2 numbers of dosing tank and 2 numbers dosing pumps. The SMBS dosing is controlled through stroke controller & the dosing rate of SMBS is controlled from ORP analyzer provided at the outlet of cartridge filter. Commercially SMBS (100%) is available in Powder form, in dosing/preparation tank 10 % solution is prepared for dosing. SMBS is continuously available for dosing; Based on the variation in ORP value entering to RO the dosage of SMBS is get adjusted through stroke controller.

REVERSE OSMOSIS SYSTEM

Osmosis is a natural process involving fluid flow across a membrane, which is said to be 'semi-permeable'. A semi-permeable membrane is selective in that certain components of a solution, usually the solvent can pass through, while others, usually the dissolved solids cannot pass through it. The direction of solvent flow is determined by its chemical potential, which is a function of pressure, temperature and concentration of dissolved solids. In case pure water is available on both sides of a semi-permeable

membrane at equal pressure and temperature, no resultant flow can occur across the membrane, as the chemical potential is equal on both the sides. However, if any soluble salt is added on one side of the membrane, the chemical potential of the water on that side is reduced. The osmotic flow from the pure water on one side to the salt solution on the other side will occur across the membrane until equilibrium of solvent chemical potential is restored. The Thermodynamic requirement for osmotic equilibrium is that the chemical potential of the solvent be the same on both sides of the membrane. No such condition is imposed on the solute, since the membrane prevents its passage. The Equilibrium State occurs when the pressure differential on the two sides is equal to the osmotic pressure, a solution property that is independent of the membrane. The application of external pressure to the solution side, which equals the osmotic pressure, will also accomplish equilibrium. A further increase in pressure will increase the chemical potential of the water in the solution and will cause a reversal of the osmotic flow towards the pure waterside, which is at a lower solvent chemical potential relative to the solution. This phenomenon is termed as Reverse Osmosis and is the basis for a process to desalinate water without phase change. Typical Boron removal rates at pH 8 are between 73 and 90% for standard High Rejection Reverse Osmosis membranes, depending on the water temperature. Special High Boron Removal membrane can achieve a 95% removal. At 30°C

The Reverse Osmosis unit essentially works on molecular level. It separates the molecular impurities from the water thus making reject stream rich in salt molecules and other stream lean in salts thus reducing the TDS of the water. The UF permeate after removal of other contaminations except total dissolved solids is then pumped using high-pressure pumps through RO module for removal of TDS. The High-pressure pump is designed in such a way that optimum flow and pressure is maintained. Reverse Osmosis module consists of thin film composite Polyamide Membranes. The 8" X40" RO membranes are loaded in a pressure vessel of 7 elements long. The feed stream to RO system is being split into Product and reject stream by controlling the reject valve as per the desired design parameters. The entire RO train is stacked in mounting frames for easy operation and maintenance. In order to prevent the precipitation of the hardness salts and silica during cases when the concentration exceeds the solubility limit, an anti-scalant is added at the inlet of the cartridge filter, which resulted in inhibition of scales. Furthermore free chlorine present in the filtered water may result in chemical oxidation of the membranes. Hence sodium Meta bi-sulfite ($\text{Na}_2\text{S}_2\text{O}_5$) is injected at the inlet of the cartridge filter to eliminate any oxidizing elements being present in the raw water and to protect the membranes, which are the most vital part of the plant.

ULTRAFILTRATION SYSTEM

6 numbers of UF Skid each of approximately 588 m³/h of (average permeate flow) capacity are provided. As shown in the figure-8. Ultra filtration is a membrane process in which a porous membrane is used to separate or reject colloidal and particulate matter. When the Raw water treatment system is working with lean feed water quality i.e. conductivity below 210 $\mu\text{S}/\text{cm}$; only Two (2) RO skids is in service with RO permeate flow of 960 m³/hr. In this case the UF permeate water of approximately 1540 m³/hr flow is bypassed to RO Permeate tank to get the required treated raw water quality. When the Raw water treatment system is working with higher TDS feed water i.e. conductivity above 210 $\mu\text{S}/\text{cm}$; then in such case all Five (5) nos. of RO skids are in service with total permeate flow of 2400 m³/hr. In this case the UF permeate water 100 m³/hr flow is bypassed to RO Permeate tank to get the required treated raw water quality. In this condition, the control valve at each UF skid is throttled to generate total UF permeate of 2585 m³/hr. required controls for this arrangement are provided with auto valve based on conductivity value .As shown in the figure -8.

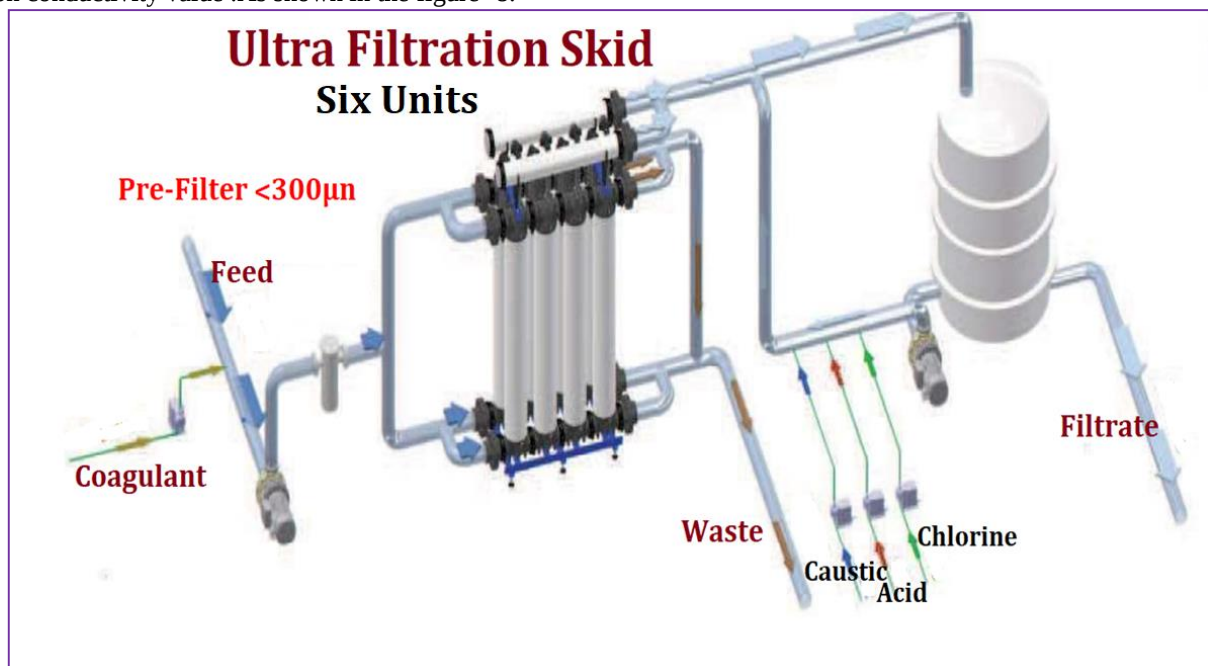


Fig-8

Treated Water Quality

Sr. No.	Description	Unit	Product water quality after pH correlation & Blending
1	Treated Raw water	M ³ /Hr	2268
2	Calcium (++)	mg/Lit	12
3	Magnesium (++)	mg/Lit	≤1.6
4	Sodium(+)	mg/Lit	≤28
5	Potassium(+)	mg/Lit	≤1.2
6	Ammonium(+)	mg/Lit	≤6.9
7	Dissolved Boron	mg/Lit	≤5
8	Chloride(-)	mg/Lit	≤40
9	Sulphate(--)	mg/Lit	≤14
10	Fluoride	mg/Lit	≤0.03
11	Nitrate	mg/Lit	≤0.03
12	Carbonate	mg/Lit	≤0.04
13	Bicarbonate	mg/Lit	≤57
14	Reactive Silica	mg/Lit	≤0.5
15	Total Silica	mg/Lit	≤0.5
16	TDS	mg/Lit	≤150
17	TSS	mg/Lit	≤1
18	Turbidity	mg/Lit	≤1
19	pH	NTU	6.8-8.2

Table-4

TROUBLE SHOOTING

In case of operation of plant with Minimum values as mentioned in Table-2, and shown in the figure-4 dotted line UF permeate was by-passed the RO System, with Two RO train in operation. In this case the value of Reactive and Total silica is reach a value approximately 2 mg/Lit. Guaranteed value for chloride is 40 mg/L. Maximum value 52 mg/L as Cl for short term operation up to 18 days/year. The RO units are designed at minimum operating temperature of 22°C and maximum operating temperature of 34°C water temperatures. The discharge head of the RO high Pressure pumps is selected at the minimum design temperature and the Permeate TDS is guaranteed at the Maximum design temperature. The raw Water Treatment Plant is worked for continuous and 24-hour basis. All the dissolved ion concentrations are expressed as ions unless otherwise specified. Also During seasonal variation, the SBR are bypassed & raw water is directly fed to filter feed tank & further to DMF

pH CORRECTION DOSING SYSTEM

In order to meet RO, permeate pH parameters (i.e. pH range in 6.8 to 8.2). Caustic dosing provision is given to increase the pH, generally the RO permeate will be at pH of 6-7. Dosing is provided at the RO Permeate Transfer Pump discharge header, caustic dosing is controlled through stroke controller based on the pH analyzer value provided at RO Permeate Transfer Pump discharge. pH correction Dosing system comprises of 2 nos. Dosing Pumps and 2 nos. of Dosing Tanks. Caustic is available in liquid form; its commercial available concentration is 48%, for pH correction dosing is diluted to 10 % in Dosing tank. Dosage rate of Caustic is considered 5 ppm based on requirement of pH increase. Continuous dosage is considered. If grade of caustic is not clear in color, then high quality grade such as Nylon or Rayon is considering for dosing.

CALCIUM CHLORIDE DOSING SYSTEM

In order to meet RO, permeate Calcium parameters. Calcium Chloride dosing arrangement is provided at the RO Permeate Transfer Pump discharge header. Calcium Chloride dosing system comprises of 2 nos. Dosing Pumps and 2 numbers of Dosing Tanks Commercially Di-hydrated Calcium Chloride (100%) will be available in Powder form, in dosing/preparation tank 35% solution is prepared for dosing, Calcium chloride be continuously available for dosing; Based on the outlet value of Calcium in RO permeate the dosage adjusted the maximum required dosage will be 34 ppm.

DMF Backwash Waste

Dual Media Filter is backwashed daily once during normal conditions. During lean period DMF are backwashed daily twice. Total backwash wastes per filter are routed to CEB waste Sump & Backwash Waste Sump alternatively. Backwash waste routed to UF Backwash sum is recycled back along with UF backwash waste to SBR inlet to increase the overall plant recovery.

UF backwash Waste

UF backwash waste is generated after each filtration cycle of each skid. The same is stored in Backwash waste sump (RCC construction) along with DMF backwash waste. This is recycled back to inlet of SBR to increase the overall plant recovery.

UF CEB Waste

UF CEB is done once in a day. The Chemical CEB waste is Stored in UF CEB waste sump (RCC construction) along with SBR sludge. This is disposed by UF CEB waste transfer pumps.

RO Reject:

High Pressure RO reject is directly routed to RO rejects outfall piping.

OUTFALL PIPE LINE & SUB-SEA DIFFUSER PIPING FOR REJECT DISPOSAL

The material of construction of the pipe is HDPE. Size of the pipe shall be 630 mm OD. Laying of the underground and above ground outfall piping is done by others. A subsea HDPE piping of 1 km with a diffuser system has also been included.

CONCLUSION

This study confirms stability in the physical and chemical factors of Lekki Lagoon. The spatial distributions were relatively stable while there was a distinct seasonal variation in most cases. The salinity value variation from 0.3 psu to 6.0 psu. In case of variable TDS, the numbers of options are available in RWTP. The operation is differing in wet and dry seasons and dosing also varies in that cases. In case of operation of plant with Minimum values as mentioned in Table-2, UF permeate is by-passed the RO System, with Two RO train in operation. In this case the value of Reactive and Total silica was reached a value approximately 2 mg/L. In case of High values all equipment's can be taken in line. For carbon source for SBR natural molasses is used. The generation reaction chamber stems are based on underwater concept which is the safest and most reliable technology for generation of ClO₂. The reaction chamber is designed in such a way that it would be able to produce chlorine dioxide instantaneously in a controlled underwater environment and in-situ. The Boron quantity is high in Lekki lagoon and it have removed in RO units.

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LENGEND

RWTP-Raw water treatments Plant, DMF-Dual media filter, UF-Ultra filtration, SMBS-Sodium Bi Meta sulphite, ORP-Oxidation Reduction potential. PSU- (Practical Salinity Unit, CEB-Chemical Enhanced backwash, HDPE-High Density Poly Ethylene. VFD- variable frequency drive.