A TEHCNIAL BRIEF – CENTRALIZED BIOLOGICAL TREATMENT PLANT

FSTP -1 , camp 4 extension

Constructed, commissioned, and operated by **OXFAM**

Commissioned in December 2018, Inaugurated in Feb ,2019

Operated by – **NGOF** (From 1st January 2022)

Funded by **UNHCR**

This document is prepared by OXFAM

Brief :

Given the scale of the refugee influx and the speed at which displacement occurred, the need for clean and safe sanitation facilities has been a constant challenge. The breakneck speed at which the crisis unfolded meant that some emergency facilities were installed on a temporary basis, and waste management has been a huge concern with high levels of diarrhea, respiratory infections and skin diseases like scabies – all related to poor sanitation and hygiene. The density of the settlement and hilly terrain have also exacerbated the issue, as the ground is susceptible to landslides, flooding and erosion.

The Ukhiya mega-camp now shelters more than 630,000 people and managing the waste produced is an area that requires specialist skills and resourcing. The unplanned manner in which the camps sprang up meant that suitable land for latrine pits and fecal sludge treatment are in short supply. This plant has been designed in such a way to avoid major civil structure weather emphasized on earth work but durable components. However, the refugee beneficiary who are living close by were well consulted before and during the plant construction work as well as around 3800 man-days cash for worker from the community were involved during the first phase construction work.

In order to address the pressing need for waste management, Oxfam has partnered with UNHCR and Bangladesh government to build the largest Fecal sludge treatment plant ever built in a refugee camp. The industrial-scale plant can process the waste of 150,000 people.

After three years of successful operation, OXFAM handed over this Fecal sludge Treatment Plant to one of the prominent WASH agency in Bangladesh , NGO Forum for public health . Since January ,2022 NGOF is operating this treatment plan and for ensuring smooth transition , OXFAM continuing to provide technical support ,undertaking modification task for increased capacity from 120m3 to 180m3 and concentrated on waste to energy project to reuse the bi product (Biogas , biolsolid) of the plant.

Objective

Having a proper collection and fecal sludge treatment system will ensure functional and hygienic latrine for the Rohingya community and contribute to reduce the public health risks and keeping the water bodies pollution free.

Capacity and Coverage

The camp coverage with the current capacity of 120m3/ day and 100m3/ day operational – This FSTP and covers Camp 3,4,4x,5 and 17 with IFSTN -1 . In addition, its supporting FS treatment for North – East camps.

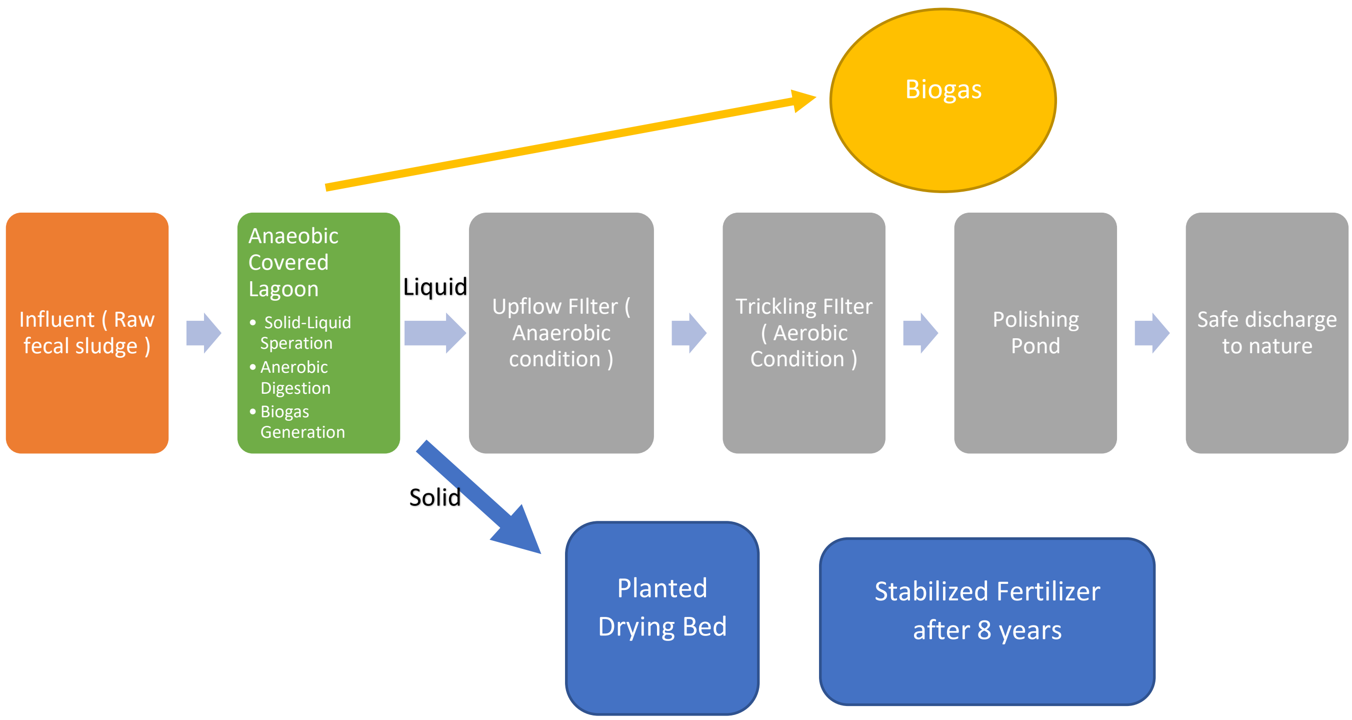
Advantages and unique features of the FTSP

- Purely biological system
- It is designed to take advantage of the gravitational flow from inlet to outlet, which means once the lagoons are full there will be no need to use pumps for the liquid waste treatment process. Eventually no external energy requires for the treatment plant.

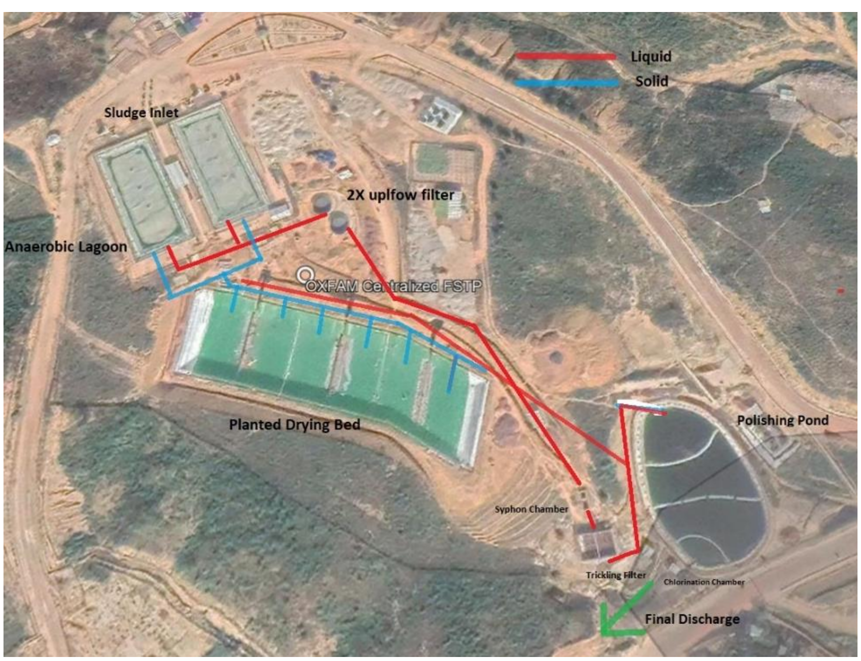
- Bio-gas will be collected to distributed to the community people for using their cooking purposes.

- Minimum operation and maintenance cost considered to design the plant keep running at least for fifteen years
- anaerobic process is a source of renewable energy that can be used to displace fossil fuels such as oil or natural gas, or to generate electricity

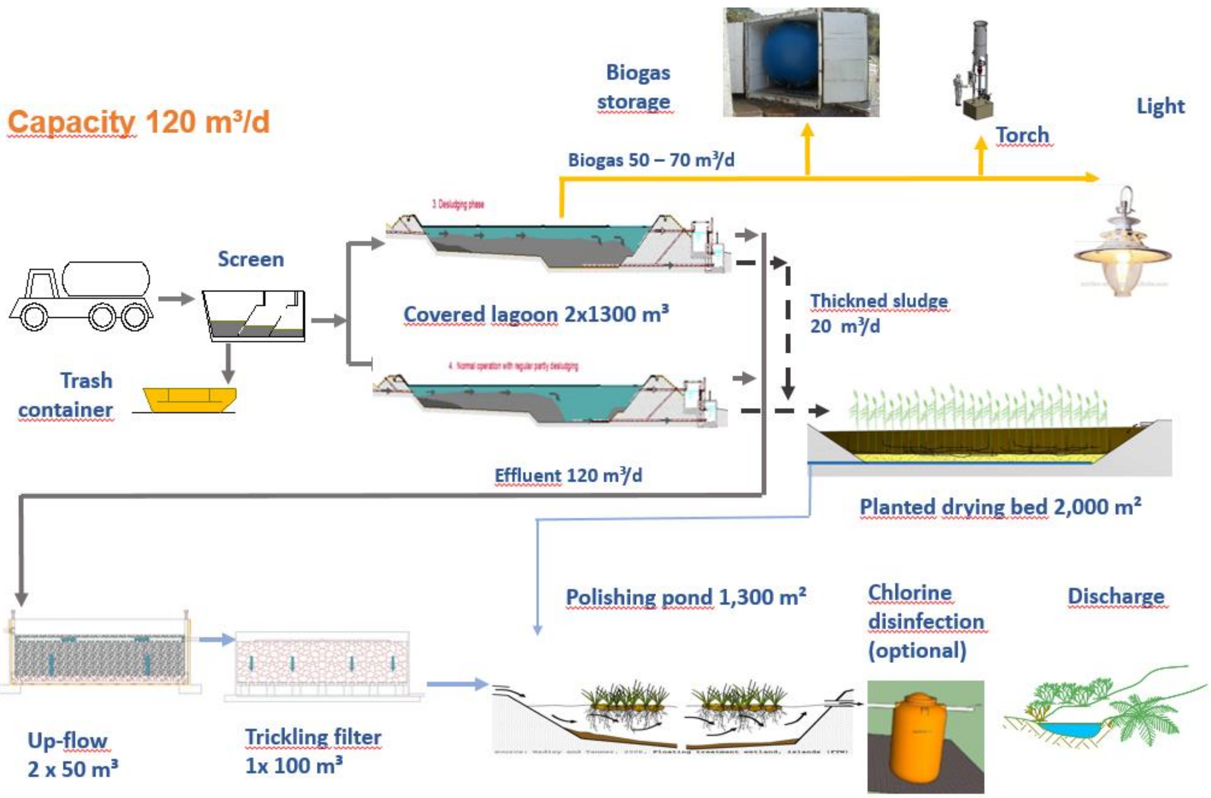
Flow diagram –



Site Layout and treatment flow



Site Layout -2021



<u>**Design Parameters and sludge characteristics**</u>

Parameter Name	**Unit**	**Value**
Design Capacity		
TS	Percentage	2.3
VS of TS	Percentage	64.3
COD	mg/l	41000
BOD	mg/l	17333
Settable Suspended Solid (2h)	mg/l	325
NH4 Mix	mg/l	800
Total N	mg/l	1267
Sludge Density	Kg/m^3	1.08
TS load	Kg/d	2800
VS load	Kg/d	1800
COD load	Kg/d	4920
BOD load	Kg/d	2080
NH4 mix	Kg/d	96
Total N	Kg/d	152

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Combined Balance of Liquid , Design of components

Parameters	*Base Line / Raw Sludge*	*Anaerobic Lagoon*	*Upflow Filter*	*Trickling Filter*	*Polishing Pond*
BOD	17333	306	214	**95**	**38**
COD	41000	1206	714	**294**	**147**
NH4		801	1216	**368**	**37**

Grit Chamber/Screen -

Each of the lagoon intake has a screening chamber with 30 to 40mm opening size before entering the sludge into the lagoon. The purpose of it to screen the large foreign materials such as plastics bottles , packets , cloths etc. This waste should be collected and transferred to solid waste management stream.

The direction of IFSTN outlet pipe shouldn't be pointed directly towards the screener to avoid pushing of the small materials into it. Screen materials is prone to corrosion, if damages provision should be kept for repairing.

Covered Anaerobic Lagoon:

Two anaerobic lagoon each with 1300m3 capacity have been constructed with earthen basin bottom layer was lined with sandwich layer of LDPE membrane(1mm thickness) and geotextile layer (300gsm)and another was with bentonite and sand layer mixture. Both lagoons are forced to be in anaerobic condition with floating cover foil ,PVC 900 grams (49.4X24.4m external dimension) . Each lagoon has 20 gravel bags equally distributed at all side hanged in the perimeter to pull the cover downwards making the inside chamaber gas tight. 3 floaters made of polystreol blocks with inner gas collection pipe collects the biogas from lagoon. A layer of fishing net has been laid on top of the cover to protect the lagoon cover from UV radiation.

This is the first layer of treatment of fecal sludge and In terms of treatment objective it works as

- Storage
- Liquid / solid separation
- Sludge stabilisation & 50% TS reduction
- Primary liquid treatment by anerobic digestion
- Biogas generation

Each lagoon has Hydraulic retention time of 21 days , Solid retention time,th – 115 days , Solid retention time ,effective 27 days. Considering 120m3 treatment capacity per day.

Treatment Mechanism –

AD widely used for biosludge treatment with the aims of volume reduction and biogas generation is a complex biological process with the multiple-steps of reactions, i.e. hydrolysis, acidogenesis, acetogenesis and methanogenesis by which organic fraction of bio sludge being mainly converted to biomethane or hydrogen, an emerging source of renewable energy.

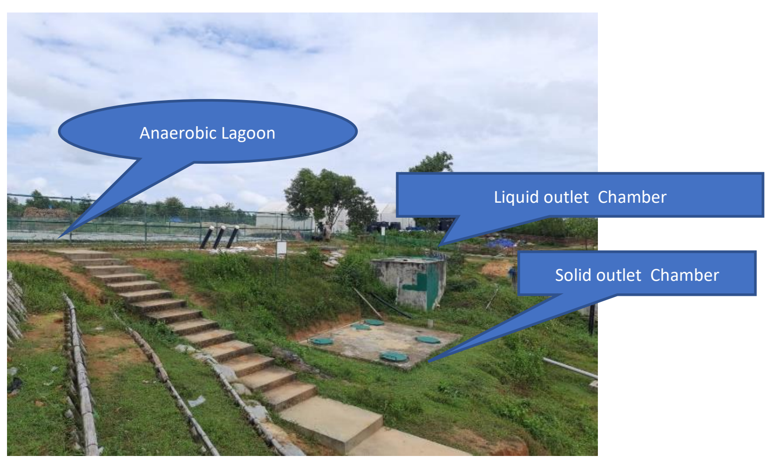
Regular O and M

Please see the O and M checklist to have a detailed idea about the day to day operation and monitoring requirement. However during rainy season attention should be given for effective drainage of the rain water accumulated above the lagoon. The gatevalve installed at lagoon liquid outlet need to controlled to avoid excessive flowrate / velocity to the upflow filer . It may wash out the bacterias from the filter media.

Biogas Generation Theoretically both of the lagoon combinedly can generate 60 to 80m3 of biogas each day with 70 to 75% of methane content . OXFAM is currently working to covert the gas to electricity after scrubbing and installing biogas generator.

Solid – Liquid chamber

Each of the lagoon has one liquid and one solid chamber which acts as a equalization chamber before passing to upflow filter (for liquid) and planted drying bed (for solid) .



Bristle filter is installed in the outlet pipe of liquid chamber for indicating lagoon performance on related to solid – liquid separation. Higher percentage of solid accumulating in the filter indicates lower efficiency of lagoon's solid- liquid separation.

Biofilm –

A complex bio-film develops on the surface of the medium which absorbs, adsorbs and metabolises the pollutants. The biofilm grows rapidly and when it becomes too thick to retain its grip on the media it washes off and is replaced by newly grown film. The washed off ("sloughed" off) film is settled out of the liquid stream to leave a highly purified effluent

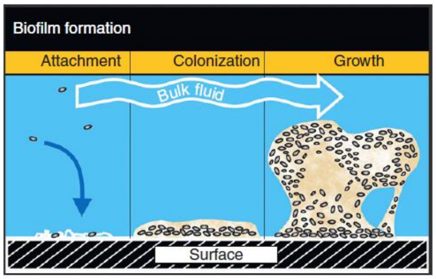
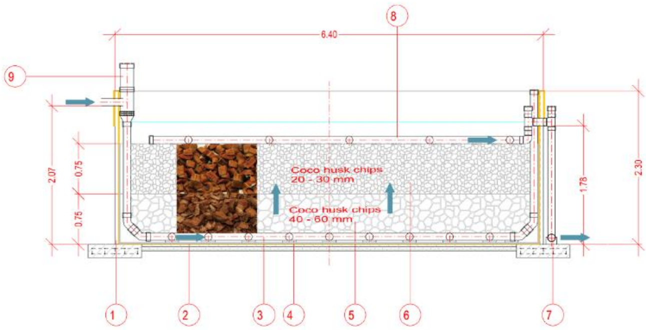


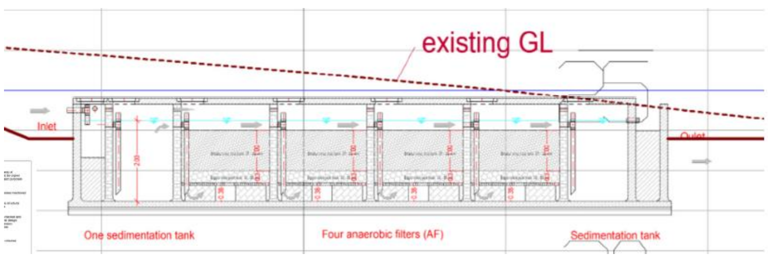
Figure 1 Steps in biofilm formation. © 1995 Center for Biofilm Engineering, MSU-BOZEMAN.

Upflow Filter –

Initially , Two OXFAM T75 tank (Each 75m3 , 6.4 m diameter) were installed and kept in anaerobic condition with submerged coconut husk media . To avoid scratch or distortion of the tank line , Sandwich layer of geotextile has been use over the liner. Two different size of cocohusk layer has been used 20-40mm of 0.75 m and 30 -50mm of 0.75m . Coconut husk has been chosen as attached media for having wide range of advantages including can slowly filters the water , Having large surface area , can trap the bacteria that are essential for biofilm formation . Atlast it is plant based, renewable and easily found locally. But after one year of performance monitoring over this upflow filter it was found that COD and BOD reduction rate was around 20% and 45% which is quite low compared to the expectation. Few possible reasons could be high COD loading from lagoon outlet , shortcuts in the cocohusk bags due to small mesh size of net, variable flowrate / loading at inlet especially in rainy season. Considering the facts new Anerobic filter reactor (AFR) was proposed to replace the previous Upflow filter.



Initial Upflow filter cross-section and image



New Anaerobic Filter Reactor (AFR), cross-section and image

Aeration Drain :

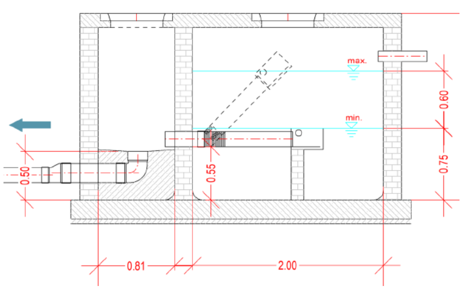
In 2021 average dissolved oxygen after the upflow and Trickling filter was observed less and increased DO can help the treatment performance of Polishing pond and improved quality of final outlet. The reading of 2021 was Upflow outlet – Tricling filter outlert – Polishing pond outlet : 1 – 2.5-1.5 mg/l

An aeration drain of 30 meter was proposed after the up flow filter to increase the DO at TF and polishing pond outlet.

Figure 1: Aeration Drain

Siphon Chamber –

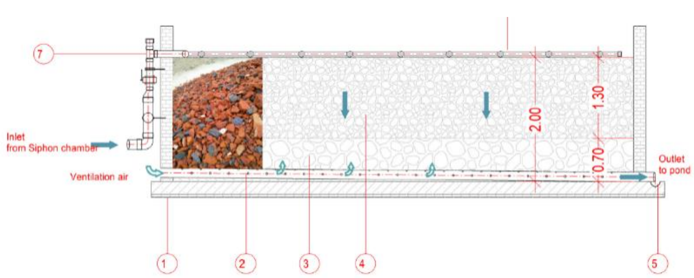
This chamber has been introduced to ensure equal and distributed flow to trickling filter. Add details 2m3 per flash and Oxfam design of $2m^3$ 6-8 times per hour over 16 hours with 20 lps flow rate onto trickling filter. 1 4" flout has been installed.



Trickling filter

Trickling Filter generally comprise a vessel packed with inert media (rocks, coke, lava, slag, gravel, polyurethane foam, ceramic, sphagnum peat moss or plastic media). The distribution system is used to sprinkle wastewater over filter media, and the wastewater trickles through the filter media supporting biomass under the influence of gravitational force. A biological slime layer grows on the media, and treatment is provided by the microbes that absorb dissolved organic matter for their growth and reproduction as the wastewater cascades randomly through the voids between the media {2}

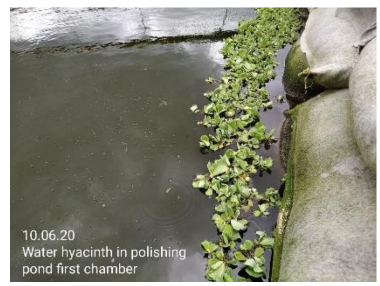
136 m3 filter volume with 76 m2 filter area , maximum 120m3/ day or 200 gm BOD per m3 per day is allowed to pass through trickling filter for effective biofilm formation and treatment. Two different sizes Bottom layer 50-80mm and top layer 30 to 50 mm of well burned bricks with maximum porosity layer of media is placed inside the TF. 160mm HDPE pipe in bottom ensure ventilation and drainage. Distribution system in the top is installed with series of 50mm HDPE pipes with 90 unit mounted BLUMBERG nozzle.



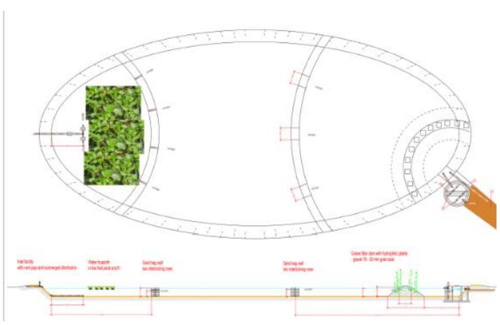
Polishing Pond-

Cox'bazar Rohingya camps being located in tropical region with UV Radiation of index between 8 to 12 which Sunshine fall between 10 to 13 hrs, Waste stabilization pond can be considered an appropriate technique for the treatment and removal of pathogenic microorganisms. The maturation ponds are used for tertiary treatment removal and relative costs include simplicity, low cost, low maintenance, low energy consumption, robustness, and environmental sustainability. The primary function of maturation ponds is the removal of excreted pathogens. Pathogens die off due to the high temperature, high pH or radiation of the sun leading to solar disinfection. Maturation ponds achieve only a small removal of BOD, but their contribution to nutrient (nitrogen and phosphorus) removal can also be significant.

With a capacity of 1400m^3 volume, 1meter depth and 11 days hydraulic retention time oval shaped maturation pond serve as the final stage of treatment with objective of the removal of pathogens, nutrients , small amount of BOD and possibly algae. The bottom layer of polishing pond is sealed with sandwich 1.5mm tarpaulin,600gsm and geo-textile layer,300gsm. There is three layer of divider with geobag filled with fine sand and coarse brick chips intended to have a layer of filtration and better mixing . Water hyacinth is planted in the first chamber so that it can take nutrients and also works as an indicator of high organic load and reduced DO.

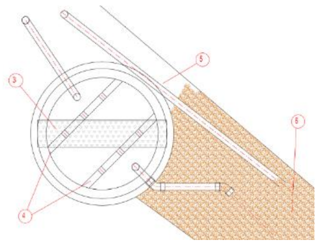


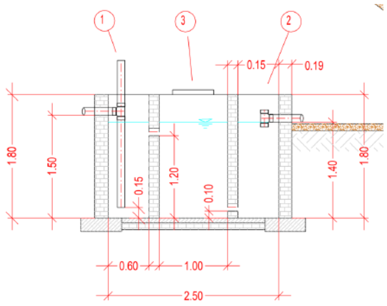
- NH4 reduction = 100%
- Nitrate reduction = 50%
- COD & BOD reduction 90%
- E.coli reduction 4 - 6 logs



<u>Chlorination Chamber</u>

Additional disinfection unit is constructed right after the polishing pond . Due to any malfunction of the system or while upgradation work if national discharge is not met them chlorination chamber is been activated. Manual constant dosing method is applied and baffles inside the chamber ensures good mixing.





Final Discharge –

After successfully passing all the treatment stages safe effluent is discharged to natural water bodies through a meandering channel where macrophytes (Canna Indica) are planted.

The effluent discharging to environment should follow the updated discharge standard.

Applicable government standards for discharge of wastewater effluent:

Parameter	Unit	The Environment Conservation Rules, 1997, Ministry of Environment and Forest. **Schedule 9 – Standards for Sewage Discharge**	Department of Environment Guidelines update 2019, **Schedule 7 – Standards for Sewage Discharge**
pH	-	-	6-9
BOD	mg/L	40	30
COD	mg/L	-	200
Nitrate	mg/L	250	250
Phosphate	mg/L	35	35
Total Nitrogen	mg/L	-	15
Suspended Solids	mg/L	100	100
Temperature	°C	30	30
Coliform	CFU/100mL	1000	1000
Oil & Grease	mg/L	-	10

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Planted Drying Bed:

Figure 2: Planted drying bed ,2021

Digested and settled sludges from both anaerobic lagoon is transferred to planted drying bed with gravitational force. The main objective of this component is storing , dewatering, drying, mineralization and sanitizing fecal sludge.

Macrophytes therefore play an essential role in the following:

• Stabilising the beds to prevent media erosion and clogging, and improving the drainage;
• Increasing moisture loss (through evapotranspiration, in contrast to only evaporation in unplanted
drying beds);
• Providing a surface area for microbial growth within the sludge layer;
• Transferring oxygen to the sludge layer (i.e. within the rhizosphere) and absorbing heavy metals and nutrients

Figure 3 : Planted Drying Bed ,Year 2020

Dam line sandwich system consist of total four layer of first layer of tarpaulin ,400gsm second layer of PE membrance,1.5 mm and third layer of Geotextile ,300gsm. Three different layer of filter media is chosen for effective dewatering from bottom layer - 200mm ,8 to 12 mm boulder stone ,middle layer- 150mm height 1 to 8 mm stone chips , Top layer – 200 mm height .006 to 4 mm (60 to 80%) washed (U=d60/d10=3 to 5).

Total area of planted drying bed is 2040 sqm which is divided into six equal chamber of 340 sqm. Everyday max 20m3 ,avg 5 to 10 cm height TS-5% is charged into each bed. Meaning all 6 beds will be used chronologically one after one everyday so that each bed gets a resting period of 4 to 6 days.

110 mm diameter uPVC ventilation pipe is installed with drainage pipe to ensure sufficient oxygen supply for the plant root and bacteria. the oxygen in the air diffuses through the spaces within this granular medium that is colonised by roots and an abundant and particularly nitrifying biomass. The presence of oxygen at this level is fundamental to enabling the reeds to grow abundantly in an organic medium that could rapidly become fermenting, anaerobic and toxic. Filtrate of the PDB is collected with a series of perforated drainage pipe from PBD bottom bed and transferred to polishing pond for farther treatment .

Water level at PDB is controlled from water level control chamber and the pipe should be vertical during the start up period of the drying bed but when plants get acclimatized and grown , the control pipe should remain lower for effective drainage.

Main challenge to PDB is finding the locally available macrophytes which can survive and tolerate high and highly variable nutrient and organic levels also able to withstand the shocks associated with sludge loading and drying. 5 shoots of suitable reed per sqm area is targeted as startup for PDB. Preliminary we are experimenting two different type of macrophytes one is canna indica and another is super nappier grass (Known as pakchung 1 grass) which is under observation.

After 8 years of operation humified and stalibilized sludge need to be removed and can be used for soild fertilizer , bioash, briquettes etc In many countries, the solid residue produced from AD of sewage sludge has been used as fertilizer for crop production as well as soil stabilizer for improving soil quality. It can also be used as fish/aquaculture food sources after vermicomposting, converting the biosolids into aquatic worms. The worms mainly consist of protein and smaller fractions of fat, sugar and ash but contains low amount of heavy metals, which has a broad application potential as fish feed (Elissen et al., 2010).

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For any further queries
Safwatul Haque Niloy , Sanitation Coordinator ,OXFAM , Email: Sniloy@oxfam.org.uk
Al Rahat , PHE Officer , OXFAM , Email: Arahat@oxfam.org.uk