Climate-resilient WASH infrastructure in the Lake Kivu Region

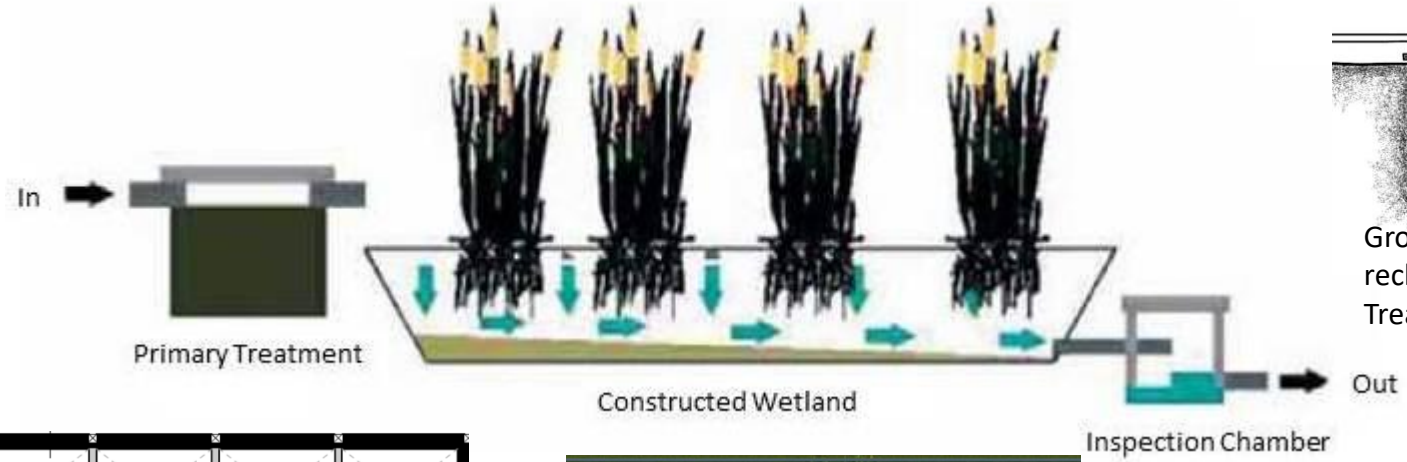
Nature Based Solutions

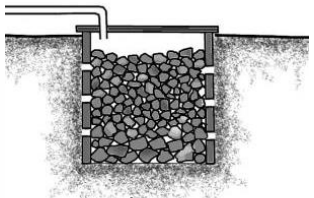
Case study: Construction of a natural wastewater treatment plant / Constructed Wetland

23 - 27 February 2026

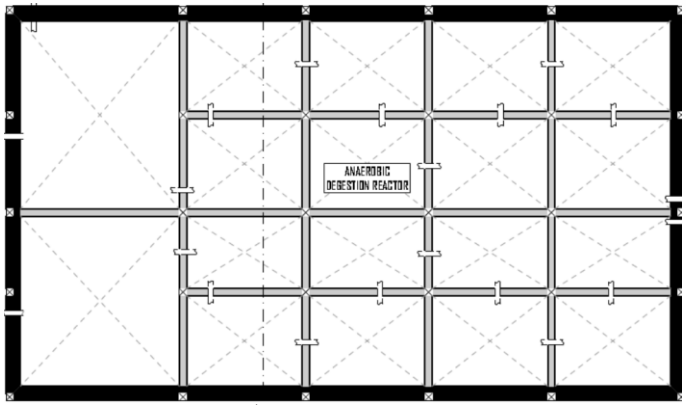
Overview of the treatment process

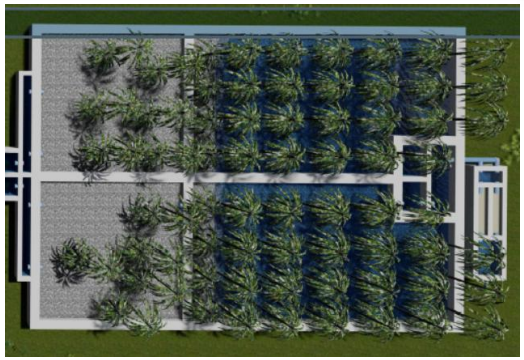
Low-flush toilet, shower, kitchen sink, etc.





Groundwater recharge, Soil Aquifer Treatment





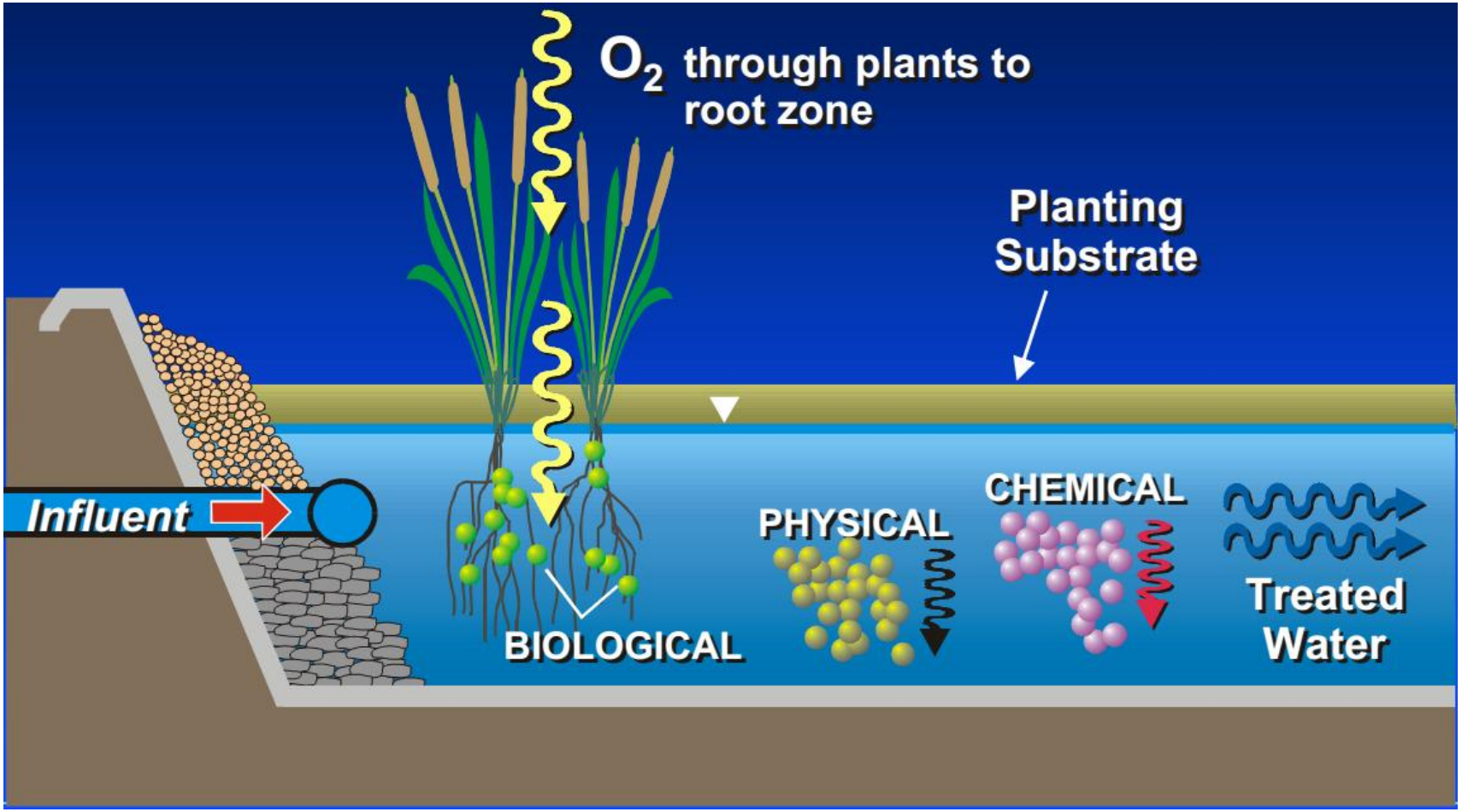
Horizontal sub-surface flow

What is a Constructed Wetland?

- **Engineered** wetlands
- Utilize natural processes
- Built in upland
- They **can replace the activated sludge part** of the conventional wastewater treatment system
- Emergent and Submergent **Vegetation**
- **Animal Life**
- **Water** that Simulates Natural Wetlands
- **Sand, gravel, rock**

Contaminant Removal Mechanisms

Multiple Processes at Work



Specific Removal Processes

Contaminants Removal Processes

- **Physical**
  - Sedimentation and Plant Trap Sediment
- **Biological**
  - Phytodegredation – uptake through roots
  - Rhizodegredation – secretion of contaminants
  - Phytovolitization – transpiring of contaminants
  - Bacteria – soil bacteria metabolize organics
- **Chemical**
  - Adsorption – transfer of ions to soil particles
  - Precipitation – converting metals to insoluble forms
  - Photo oxidation – uses sunlight to breakdown and oxidize compounds
  - Volitization – breaks down compounds and expels as gas

Case study:

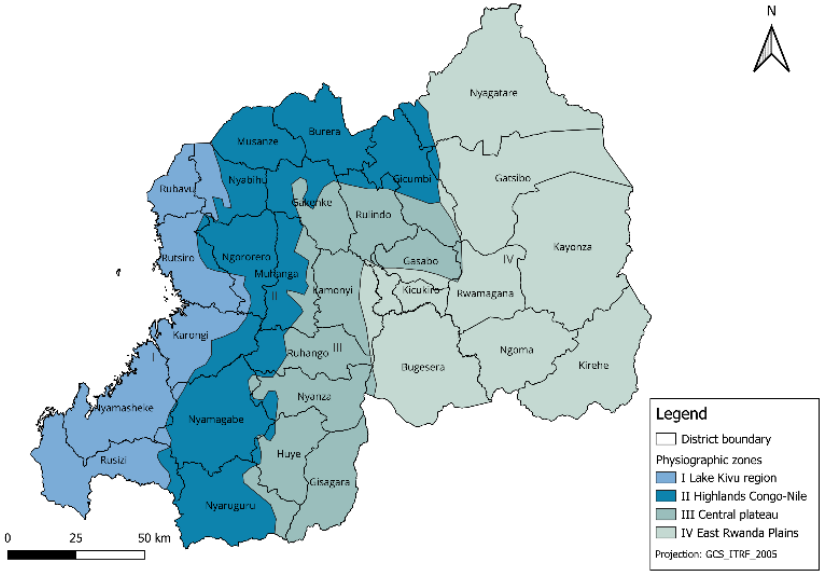
Construction of a natural wastewater treatment plant (Constructed Wetland) at Rugerero IDP Model Village, Rubavu District (2023)

Case study: Rugerero – Rubavu Model Village

Source: https://www.flickr.com/photos/rwandadefenceforce/albums/72177720309532497/

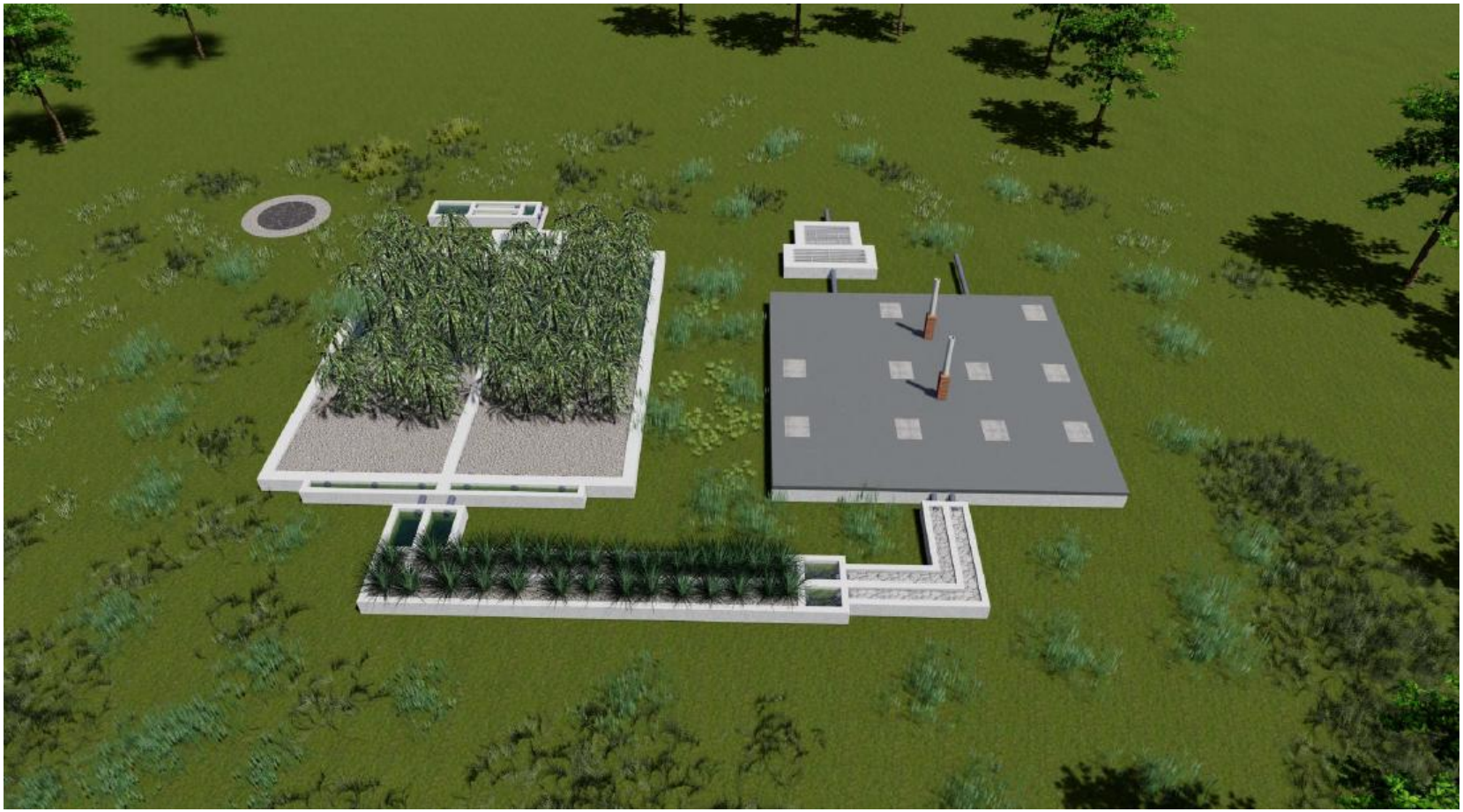
Case study: Rugerero – Rubavu Model Village

Case study: Rugerero – Rubavu Model Village



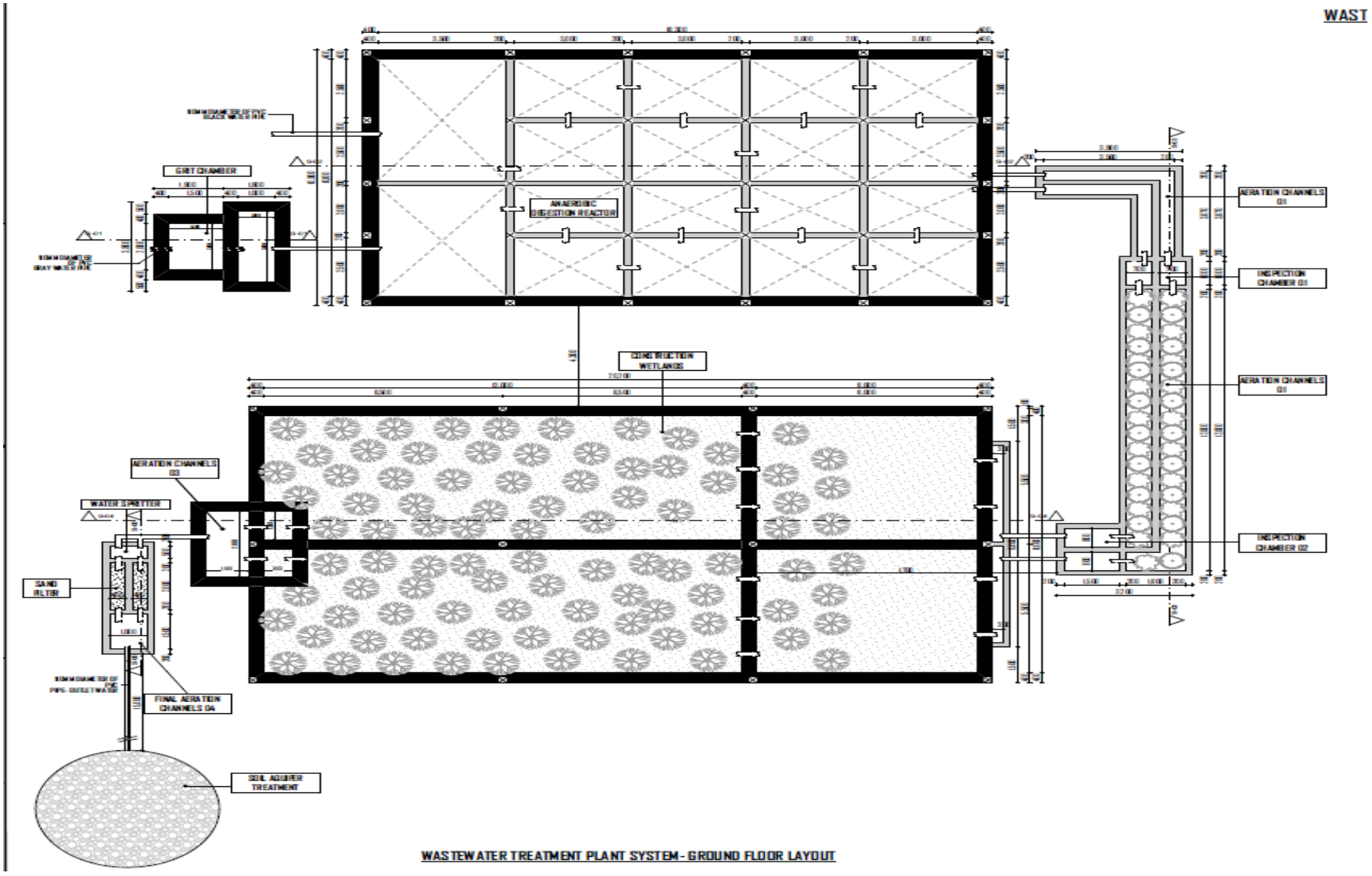
- Number of Households: 320
- Estimated population: 1,376

Perspective View



Chamber	Length (m)	Width (m)	Height (m)
#1 Anaerobic reactor	19	14	3.5
#2 Constructed Wetland	25	14	1.5

Design overview



Design overview

Design overview

Design overview

Design overview

Design overview

Operation and Maintenance

- CWs constantly require **basic maintenance** throughout the duration of its life but its relatively simple (no high-tech appliances or chemical additives)
- It is important to **ensure** that **primary treatment effectively** lowers organics and solids concentrations
- The ***pre-treatment facility*** (e.g. anaerobic digester tank) should be emptied periodically and sludge discharged in a safe way properly

Operation and Maintenance CW at Rugerero IDP Model Village, Rubavu District

Summary Maintenance Schedule

- **Daily:** Check inflows and outflows, look for signs of leaks or malfunctions.
- **Weekly:** Inspect Anaerobic Digestion Reactor access points and surrounding areas.
- **Monthly:** Inspect plant bed for even growth, check for invasive species.
- **Quarterly:** Perform water quality tests (4 to 6 months) and adjust HRT if necessary.
- **Annually:** Check Anaerobic Digestion Reactors storage level every year, and record the sludge level.
- **After 4 to 5 years:** Comprehensive inspection of the entire system, including desludging the septic if required[1].

Note: The removed fecal sludge will be collected and treated by a private licensed company sludge waste transporter, which will transport and handles the sludge generated for processing into organic fertilizer according to the approved standards for fertilizer production.

Ver: Sept 2024

Typical direct measurement of inflow characteristics

Sampling site :Rugerero IDP Model Village Waste Water Treatment Plant

2. **RESULTS**

	Parameters	Unit	Test Method	Results	RS 110 2017
				Black inlet	Tolerance Limit of Discharged domestic wastewater
1.	pH		ISO 10523	7.78	**5 – 9, range**
2.	Total Dissolved Solids	mg/l	ASTM D5907-13	390	**1500, max**
3.	Dissolved Oxygen	mg/l	ISO 17289	1.99	**3, min**
4.	Total Suspended Solid	mg/l	ISO 11923	5060	**50, max**
5.	Nitrite	mg/l	ISO 6777	3.9	**1, max**
6.	Nitrate	mg/l	ISO 15923-1	52.1	**10,max**
7.	Ammonia	mg/l	ISO 11732	92	**5,max**
8.	Total Nitrogen	mg/l	ISO 5663	183.7	**30,max**
9.	Total Phosphorus	mg/l	ISO 17294-2	105.6	**5, max**
10.	BOD	mg/l	ISO 5815-2	6447	**50, max**
11.	COD	mg/l	ISO 15705	7980	**250, max**
12.	Feacal Coliforms	Cfu/100ml	RS ISO 4831	$2.18 X10^{8}$	**400, max**

Outlets characteristics

	Parameters	Unit	Results	Test Method	RS 110 2017 Tolerance Limit of Discharged domestic wastewater
			Out let		
1.	pH		7.77	ISO 10523	**5-9, range**
2.	Total Dissolved Solids	mg/l	1076	ASTM D5907-13	**1500, max**
3.	Dissolved Oxygen	mg/l	3.33	ISO 17289	**3, min**
4.	Total Suspended Solids	mg/l	42	ISO 11923	**50, max**
5.	Nitrite-Nitrogen	mg/l	0.86	ISO 6777	**1, max**
6.	Nitrate-Nitrogen	mg/l	8.39	ISO 15923-1	**10, max**
7.	Ammonia-Nitrogen	mg/l	4.87	ISO 11732	**5, max**
8.	Total Nitrogen	mg/l	23.04	ISO 5663	**30, max**
9.	Total Phosphorus	mg/l	4.73	ISO 17294-2	**5, max**
10.	BOD	mg/l	49	ISO 5815-2	**50, max**
11.	COD	mg/l	136	ISO 15705	**250, max**
12.	Feacal Coliforms	Cfu/100ml	4.52×10^5	RS ISO 4831	**400, max**

Advantages & Disadvantages of CWs

- **Advantages:**
  - Inexpensive to construct
  - No chemicals required
  - Can be built and repaired with locally available materials
  - Very low operation and maintenance costs
  - Utilisation of natural processes
  - Efficient removal of suspended and dissolved organic matter, nutrients and pathogens

- **Disadvantages:**
  - Permanent land required
  - Requires expert design and supervision
  - Moderate capital cost depending on land, liner, fill, etc.; low operating costs
  - Pre-treatment is required to prevent clogging
  - Low tolerance to durable cold climates
  - Electricity may be required

Thank you!