Low cost green technology for domestic wastewater treatment for reuse and beneficiation

Focus areas of presentation:

1. Self-sustainable technology requiring no chemicals or electricity
2. Algae bio-reactors
3. Impact pathway
4. SADC countries

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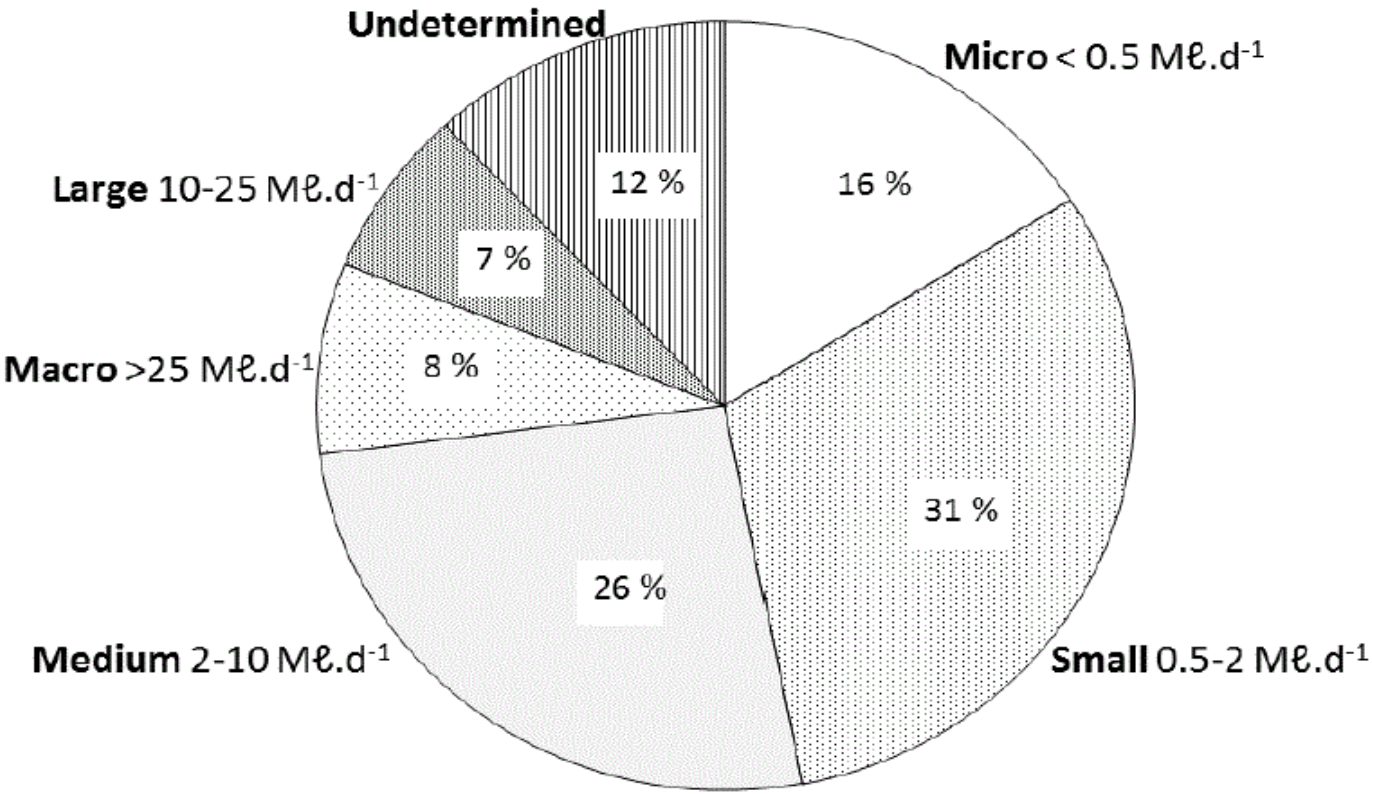
WISA, Cape Town International Convention Centre, 24 – 27 June 2018

WWTP's in South Africa



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Advanced Integrated Waste water Pond System

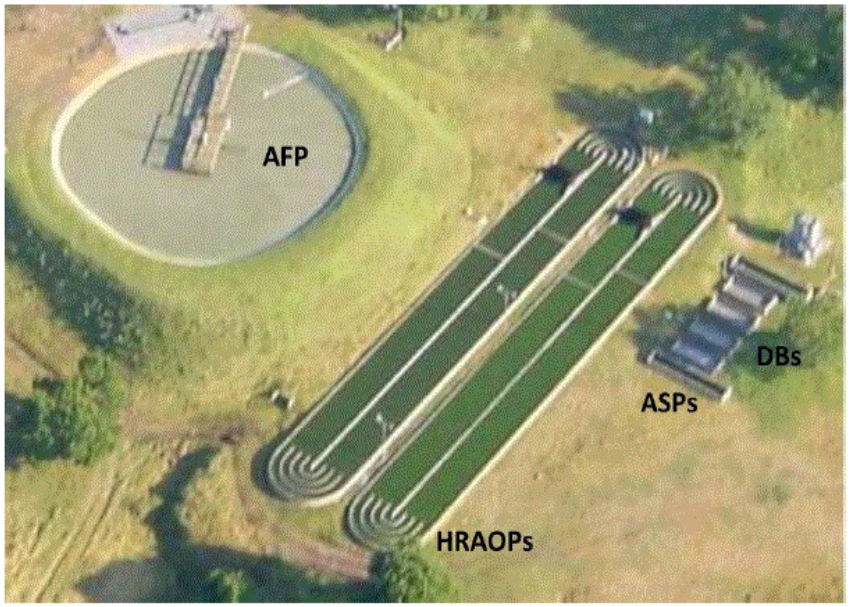

Figure 5 An aerial photograph of the IAPS pilot operating at the Belmont Valley WWTP treating 75 kℓ.d^{-1} municipal sewage. The pilot is composed of an AFP: Advanced Facultative Pond, which is a combination of an I-PD and a primary facultative pond, 2 HRAOPs: High Rate Algae Oxidation Ponds, 2 ASPs: Advanced Settling Ponds and 2 DBs: Drying Beds. Note the absence of an MP required for post treatment.

1) Use natural algae
2) Construction of algae raceway and AFP
3) Use of electricity

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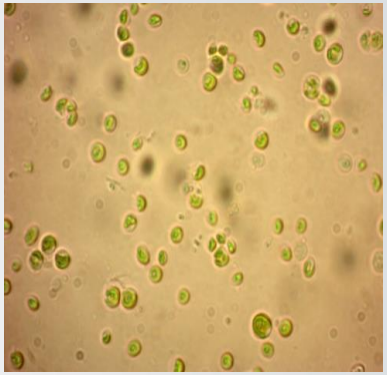
CSIR Algae Technology



1) **No electricity**
2) **No harmful chemicals**
3) **No skill labour**
4) **Use existing infrastructure**
5) **Specific algae consortium**

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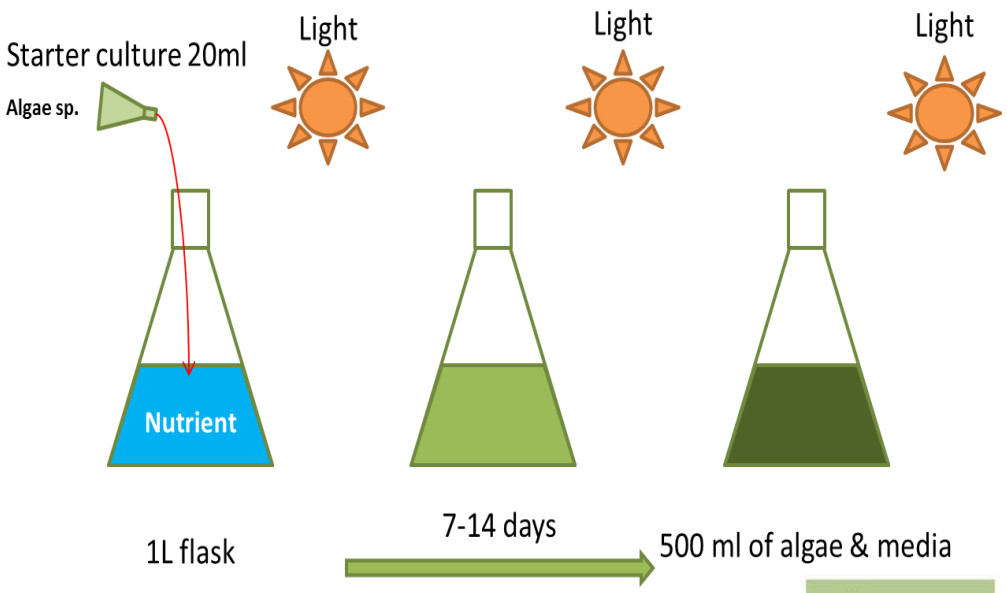
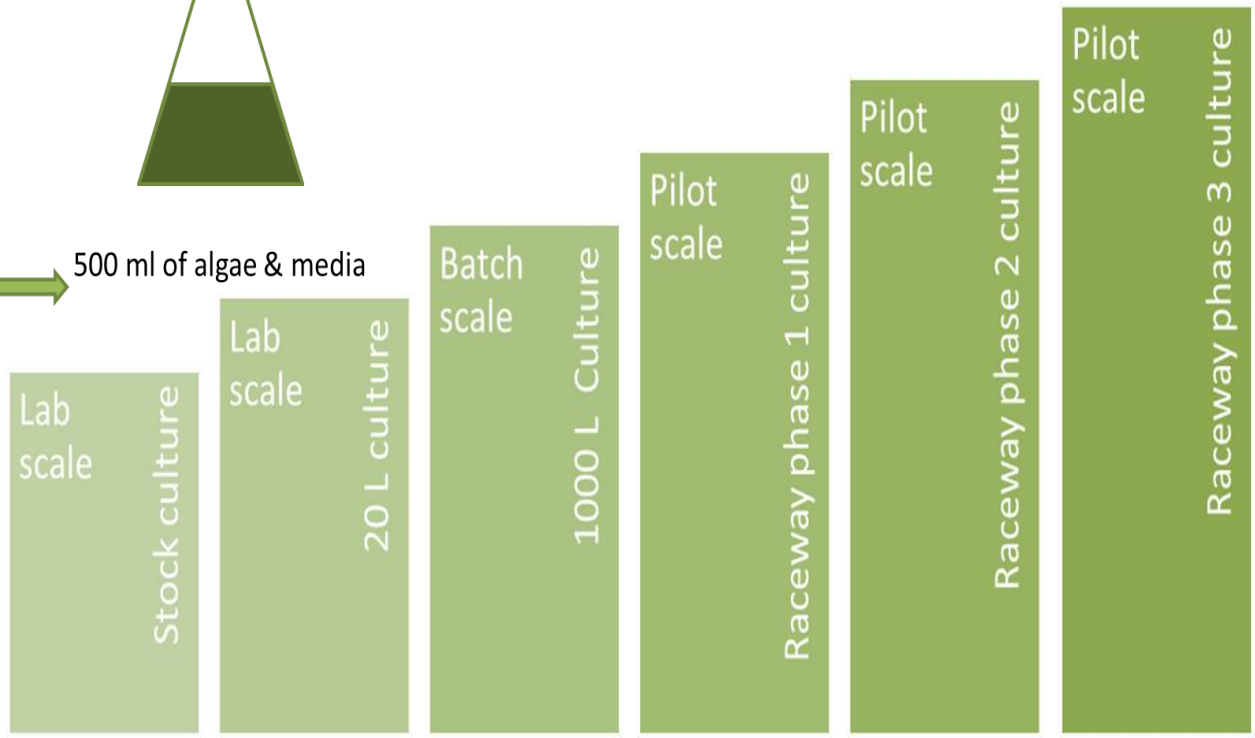
Algae cultivation

After selecting an specific consortium of algae a step wise approach was followed





Pilot study one

Motetema WWTW is situated at the small town of Elias Motsoaledi, Sekhukhune District of the Limpopo province, South Africa. Due to the lack of proper WWTW infrastructure and electricity, a series of ponds are employed at the Motetema WWTW to treat sewage effluent. The WWTW consist of 12 earth ponds organised in two series of six each parallel to one another

Characteristics of the Motetema WWTW

Six ponds are operated at a time, while the other 6 ponds are dried to remove sludge. The pond system is based on natural overflow from one pond to another. The average total effluent that needs to be treated by the Motetema WWTW is ~ 2.5 Ml/ day (currently treating 4.1 Ml/d.

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Algae bioreactors

Five semi transparent containers of 5000 litres

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Algae culturing steps

1) Inoculation time (3 to 4 weeks) of algae in the different pond systems depends on season
2) Algae are stirred manually every 4 days

Algae culturing steps

When are the algae the right colour?

Use colour codes described below

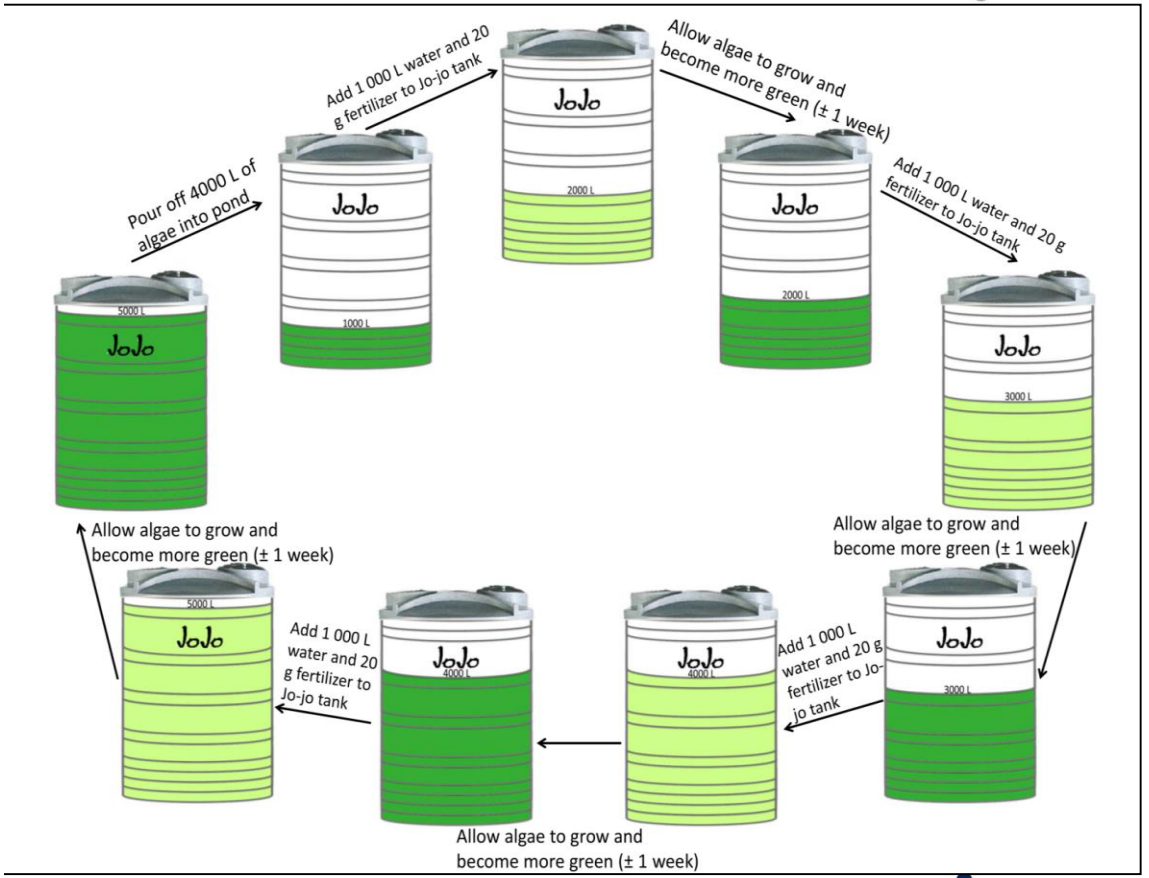
A transparent colour indicates that alga have not started to grow yet.

A light green colour indicates that algae are starting to grow.

A medium green colour indicates that algae are growing well.

A dark / rich green colour indicates that algae have reached maximum growth. Please dose ponds now.

Yellowish / brownish colour indicates that algae are starting to die off. They need nutrients. Add fertilizer.



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Data analyses

Table : Average selected parameters for monitoring the efficiency of algae for remediation in Motetema wastewater treatment works (n=5).

PARAMETERS	BEFORE (UNFILTERED)							AFTER (UNFILTERED)							REMOVAL EFFICIENCY (%)		
	Pond 1	Pond 2	Pond 3	Pond 4	Pond 5	Pond 6	Pond 7	Pond 1	Pond 2	Pond 3	Pond 4	Pond 5	Pond 6	Pond 7	Pond 5	Pond 6	Pond 7
Total Nitrogen water (mg/L)	34	30	27	23	58	31	26	47	33	36	36	33	20	18	43.1	35.1	30.7
Total Organic Carbon (mg/L)	99	61	57	47	181	45	37	117	58	77	67	55	35	31	69.6	22.1	16.4
Total Chemical Oxygen Demand (mg/L)	378	238	224	157	567	142	103	479	228	276	272	230	92	93	59.4	35.2	2.0
Total Phosphorus (mg/L)	**34**	**30**	**27**	**23**	**58**	**20**	**18**	**4.6**	**3.2**	**3.6**	**3.3**	**3.3**	**3.1**	**2.8**	**94.3**	**84.5**	**84.4**
Suspended Solids (mg/L)	229	117	115	65	224	54	76	259	118	76	120	123	82	89			
Sulphate as SO_4 Dissolved (mg/L)	87	89	106	109	71	167	153	210	150	155	159	103	122	117	39.7	63.3	23.5
Chloride as Cl (mg/L)	60	61	62	60	76	76	74	89	83	82	84	66	61	60	13.1	19.7	18.9
ortho Phosphate as P (mg/L)	**0.07**	**0.14**	**0.14**	**1.1**	**5.8**	**3.4**	**2**	**1.5**	**0.28**	**1.7**	**1.8**	**1.1**	**0.44**	**0.28**	**81.0**	**87.1**	**86.0**
Ammonia as N (mg/L)	20	17	19	18	37	24	27	33	22	21	22	21	20	18	43.2	16.6	33.3
Electrical Conductivity (mS/m)	104	102	102	98	112	100	116	132	116	120	115	120	116	94			
pH (Lab) (20°C)	8.1	8.1	8.1	8.1	7.8	8.1	8	8	8.3	8	8.7	8.9	8.6	8.2			

***1) E-coli* was reduce in the effluent of Pond 7 within DWS guideline range: General limit for *E coli* WW 1,000/100ml**

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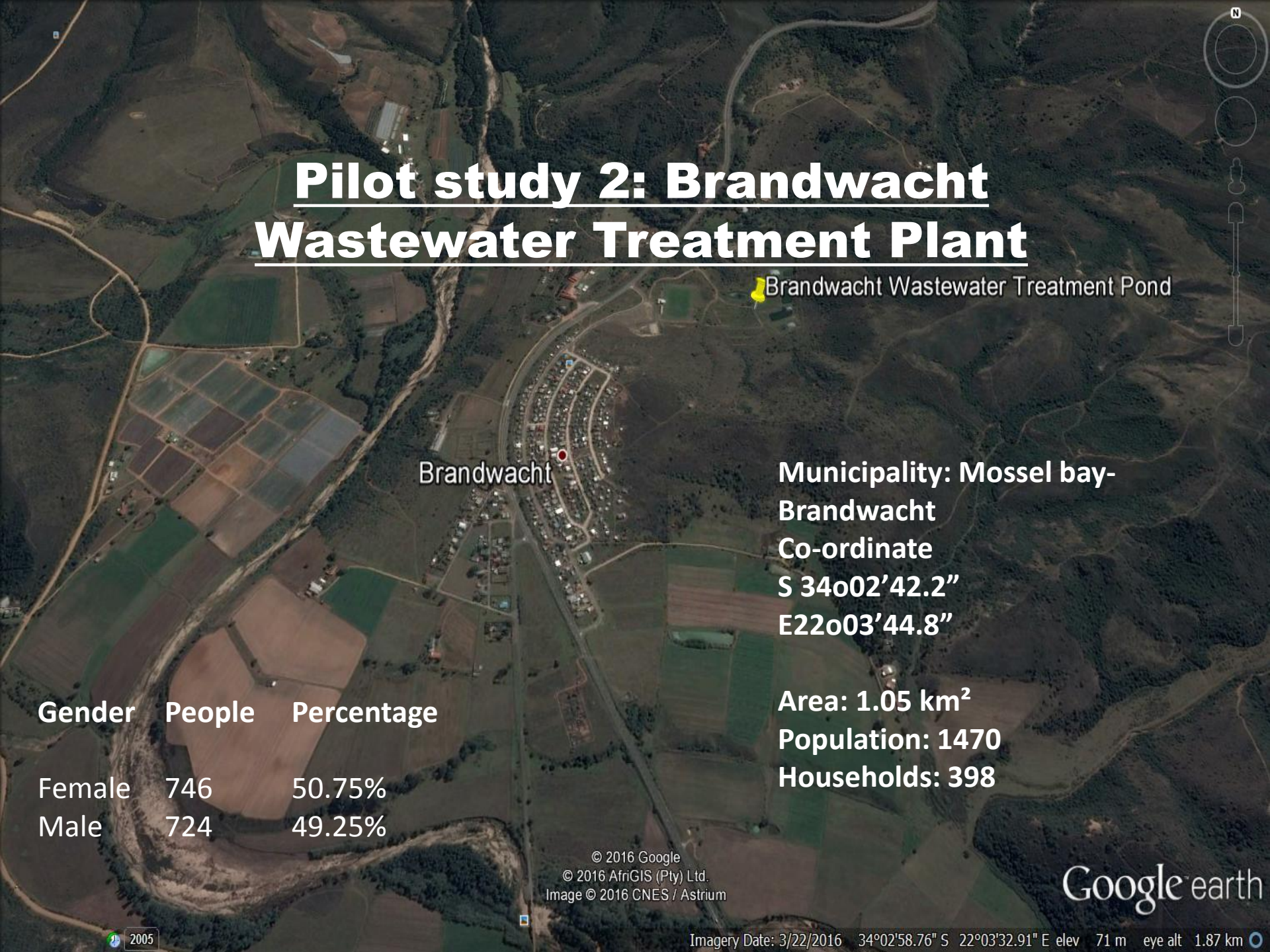
Pilot study 2: Brandwacht Wastewater Treatment Plant

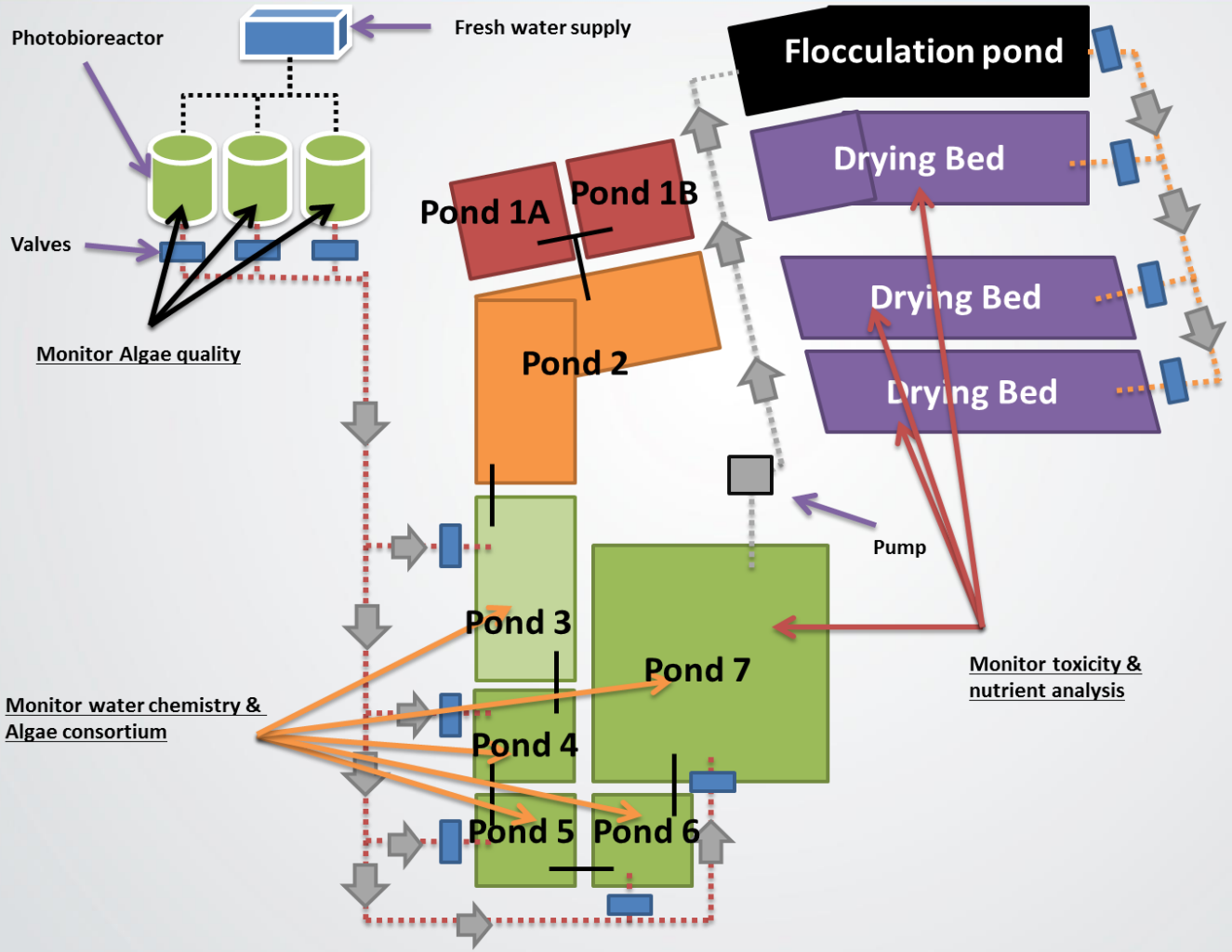


Municipality: Mossel bay-Brandwacht
Co-ordinate
S 34o02'42.2"
E22o03'44.8"

Area: 1.05 km²
Population: 1470
Households: 398

Gender	People	Percentage
Female	746	50.75%
Male	724	49.25%

Design WWTP



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Monitoring – Chemistry

Parameters		Before treatment 2017							DWS LIMITS
	Units	Dam 1a	Dam2	Dam 3	Dam 4	Dam 5	Dam 6	Dam 7	
OP_4^{3-}	mg/L	13	15	16	15	15	12	5.4	10
NH_4^+	mg/L	122	79	43	29	18	8.6	22	6
$NO_3^- - NO_2^-$	mg/L	42	49	53	54	53	57	67	50
SO_4^{2-}	mg/L	18	44	54	60	59	66	74	200
pH		8.1	8.3	8.4	8.4	8.4	8.4	9.1	5.5-9.5

Parameters		After dosing 2017							DWS LIMITS
	Units	Dam 1a	Dam2	Dam 3	Dam 4	Dam 5	Dam 6	Dam 7	
OP_4^{3-}	mg/L	20.80	18.70	2.15	1.76	1.92	1.76	2.36	10
NH_4^+	mg/L	116.00	84.00	80.00	61.00	55.00	33.00	10.00	6
$NO_3^- - NO_2^-$	mg/L	180.00	82.00	17.00	21.00	27.000	21.00	23.00	50
SO_4^{2-}	mg/L	10.00	10.00	0	0	0	0	1	200
pH		8.38	8.39	7.95	8.17	7.92	8.02	8.08	5.5-9.5

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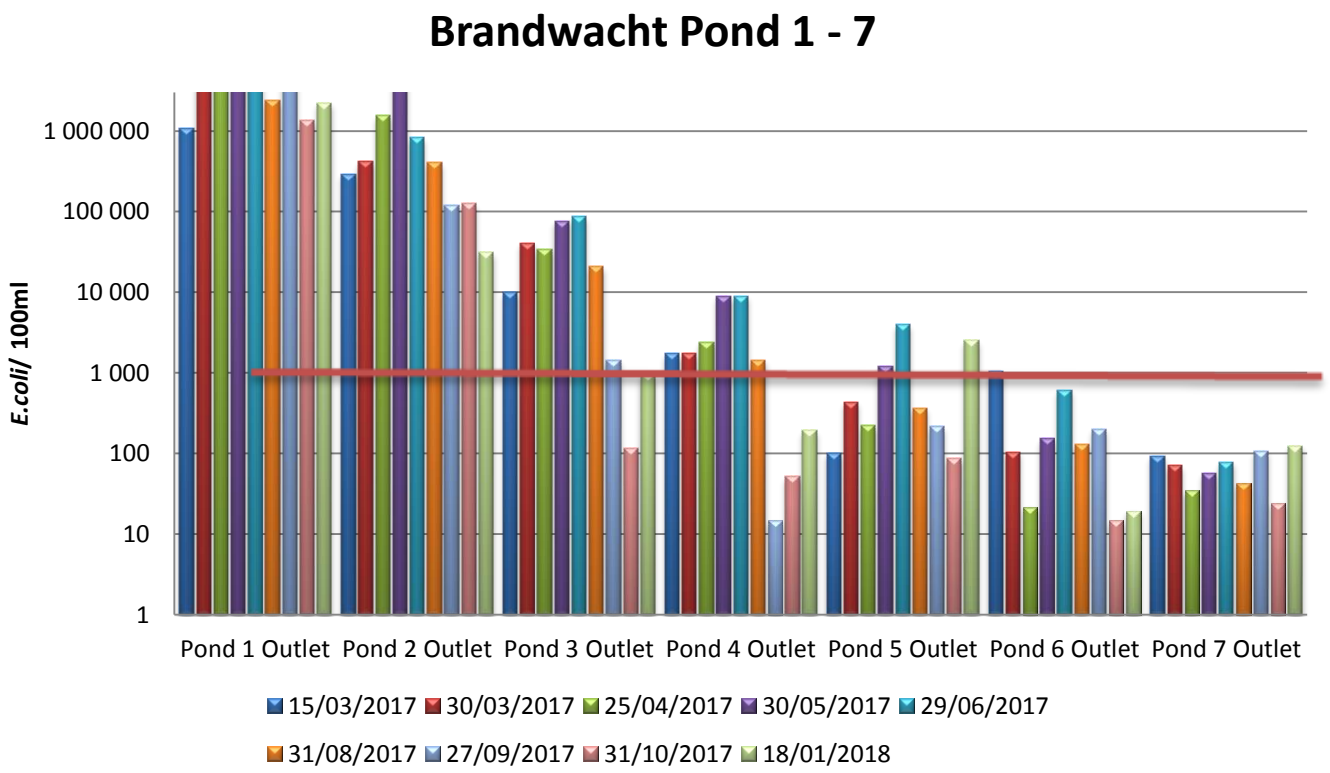
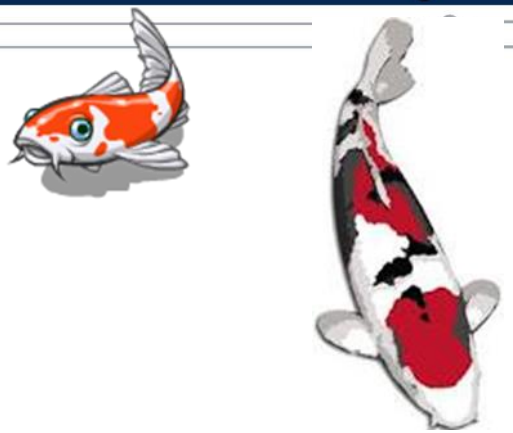
Microbial data



Removal of algae: Aquaculture



Currently experiments with the University of Limpopo are ongoing to make use of ornamental fish to reduce algae biomass in last maturated pond

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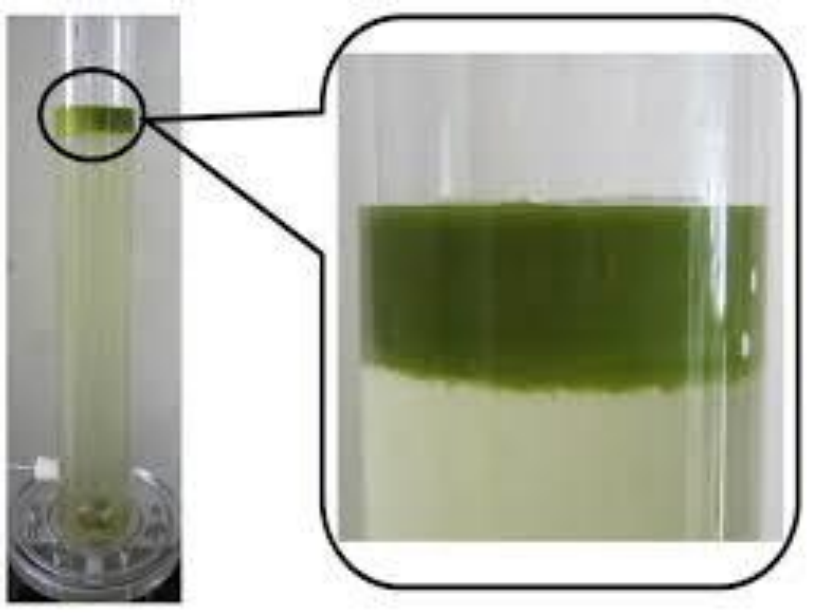
Flocculation

- Aggregation of algae to be removed from last pond
- Use of flocculants - Chitosan & alum
- Biomass was tested for use as eco-friendly fertilizer



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African Development Bank Project

African Climate Technology Centre

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- **Phycoremediation as an Adaptation Measure for Climate Change Vulnerability at Rural Wastewater Treatment plants in Southern African Development Community countries**
- **Partners:**
  - **University of Malawi (UNIMA) and**
  - **University of Botswana (UB)**

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UNIVERSITY OF MALAWI

UNIVERSITY OF BOTSWANA

MOSSELBAAI MOSSEL BAY MOSSELBAYI Explore Endless Horizons!

Project partner (UNIMA and UB) visit to Brandwacht WWTW, January 2018

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Funding agencies and collaborators

Publications

Journal of Applied Phycology
https://doi.org/10.1007/s10811-018-1554-7

The environmental feasibility of low-cost algae-based sewage treatment as a climate change adaption measure in rural areas of SADC countries

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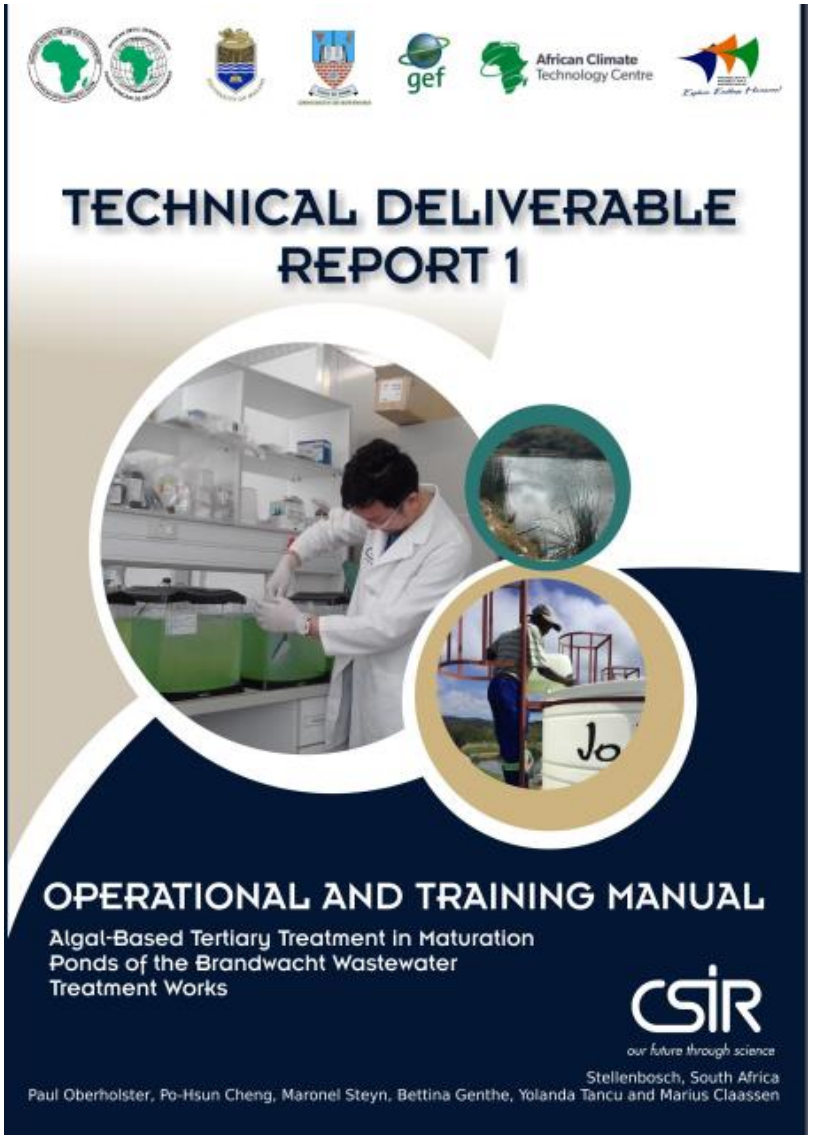
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TECHNICAL DELIVERABLE REPORT 1
OPERATIONAL AND TRAINING MANUAL
Algal-Based Tertiary Treatment in Maturation Ponds of the Brandwacht Wastewater Treatment Works
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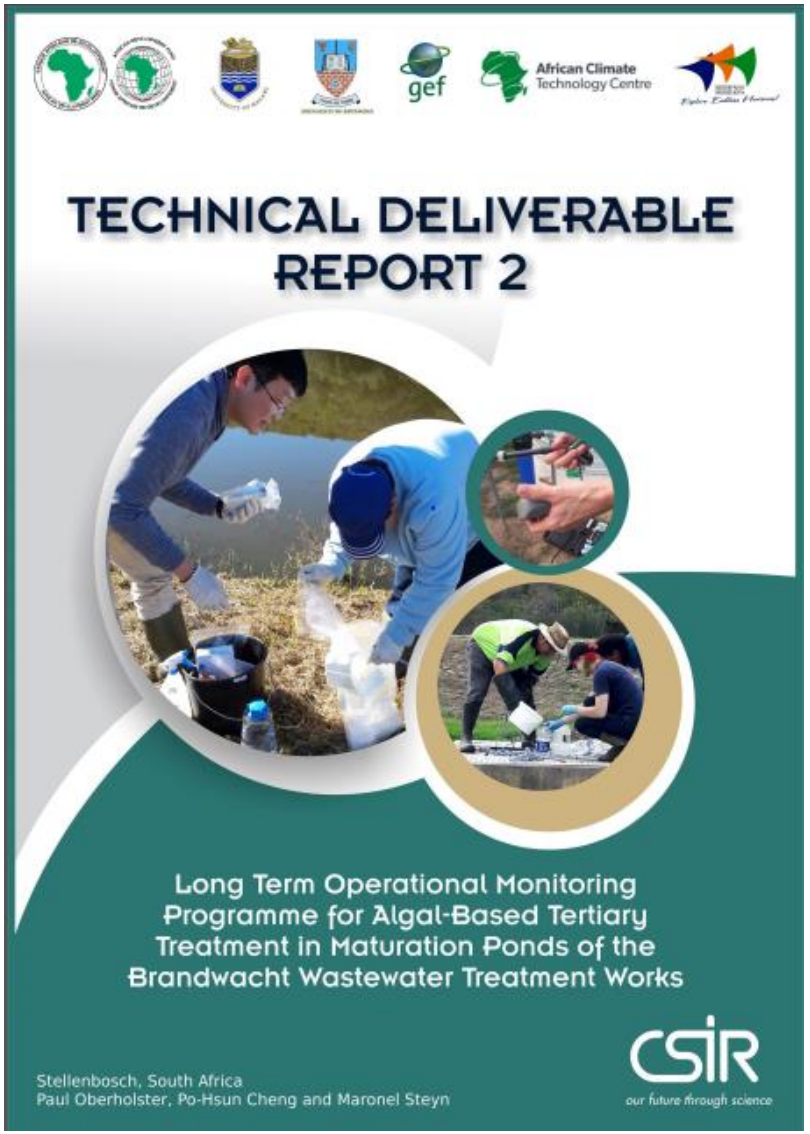
Stellenbosch, South Africa
Paul Oberholster, Po-Hsun Cheng, Maronel Steyn, Bettina Genthe, Yolanda Tancu and Marius Claassen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TECHNICAL DELIVERABLE REPORT 2
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Questions