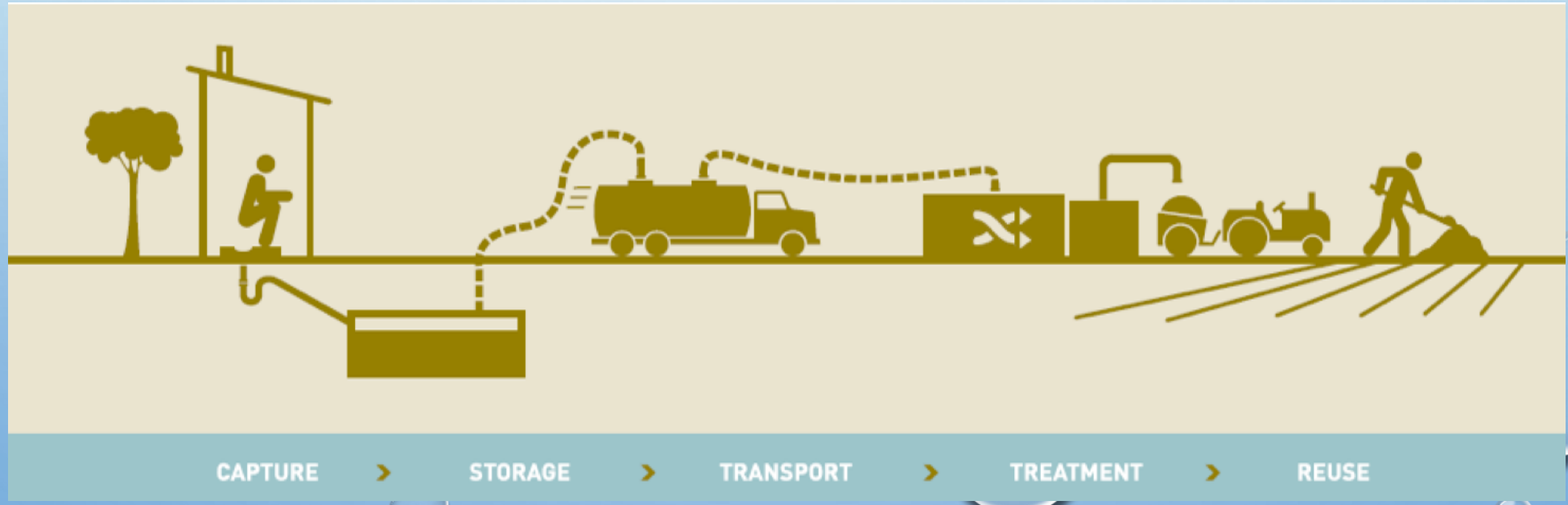
WATER-WISE SANITATION INNOVATION AND FUTURE PERSPECTIVES

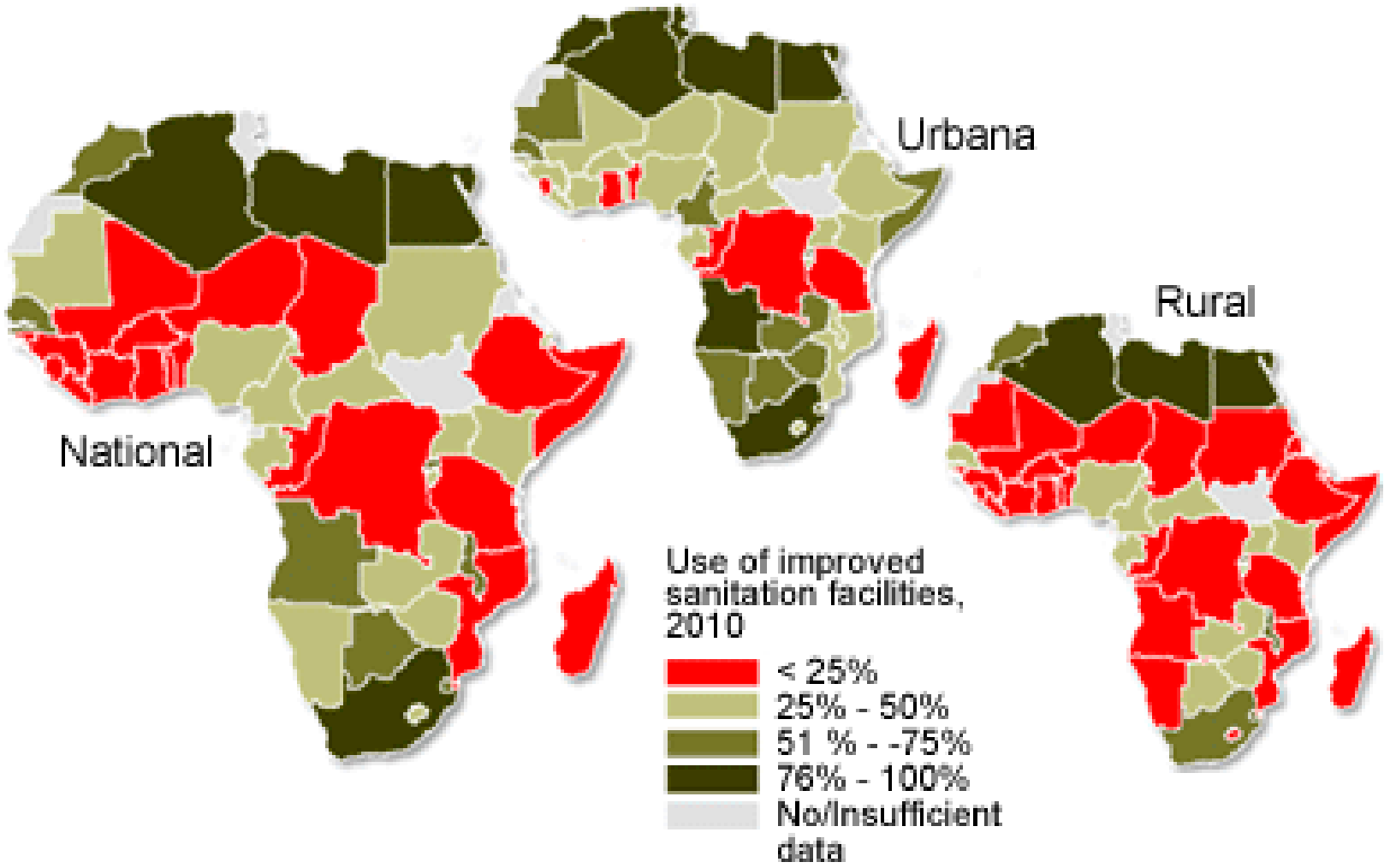
POLLUTION RESEARCH GROUP, UKZN
DR TINA VELKUSHANOVA AND DR SANTIAGO SEPTIEN



AFRICAN REALISATIONS

- **FAST GROWING INFORMAL POPULATION**
- **WATER SCARCITY**
  - BASIC WATER AS A ***HUMAN RIGHT***
  - TECHNICAL METHODS OF MANAGING WATER USE
- **SANITATION PROVISION**
  - LARGE BACKLOG
  - WATER BORNE SANITATION SERVICE TOO EXPENSIVE AND SLOW
  - MULTIPLE DELIVERY MODES
- **VULNERABLE POPULATION**
  - FOOD
  - EMPLOYMENT
  - HOUSING
- ***ASSIMILATIVE CAPACITY OF AGRICULTURE***

In 18 countries in sub-Saharan Africa a less than a quarter of the population uses and improved sanitation facility



A snapshot of Drinking Water and Sanitation in Africa-2012 Update. AMCOW, WHO/UNICEF JMP, 2012

SCARY FACTS
AND THEN JOIN THE DOTS

- WORLD

  2004:

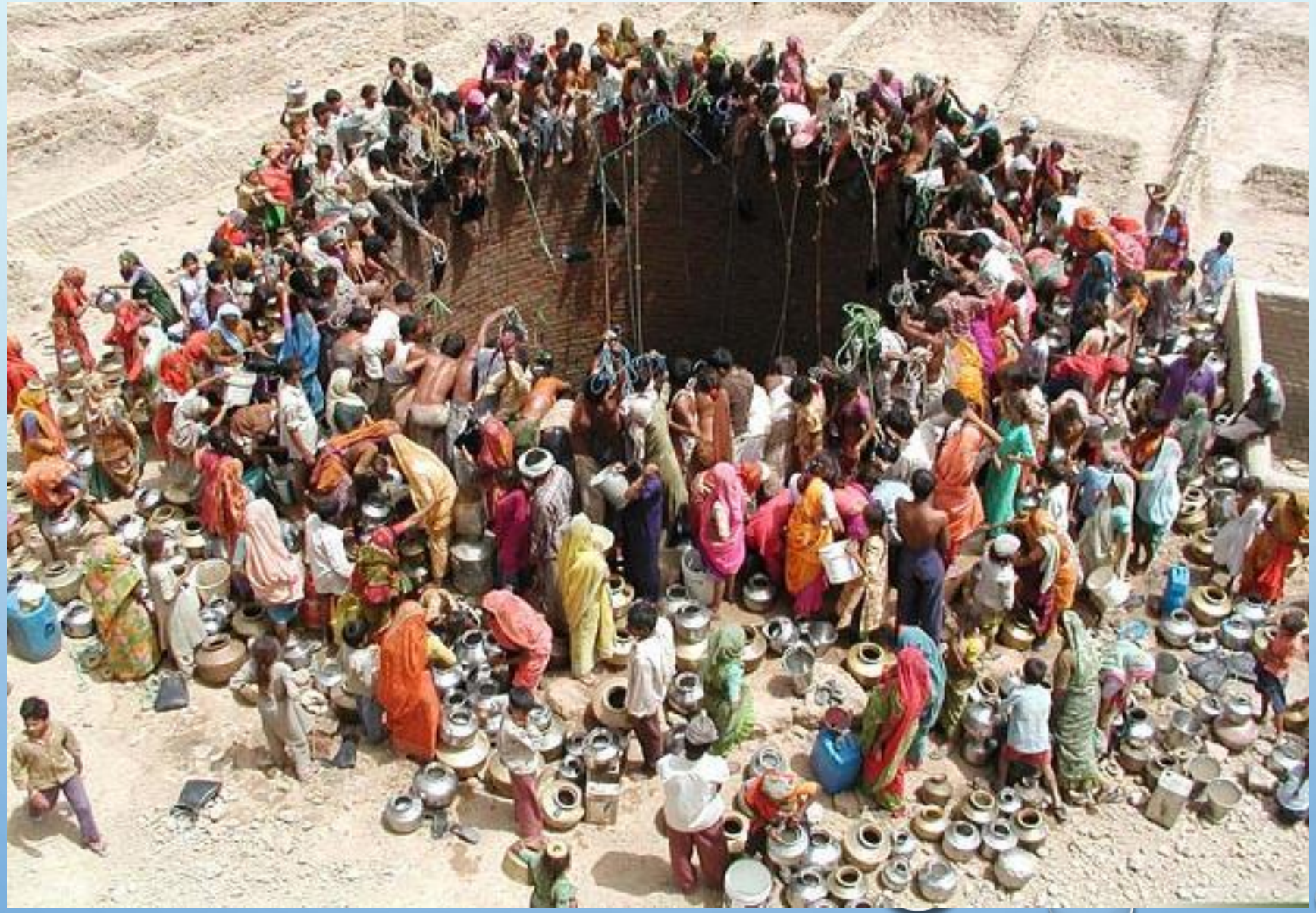
  - 3.6 BILLION, I.E. 42% LACKED ADEQUATE SANITATION.
  - 330 MILLION, I.E. 5% HAVE ADVANCED SEWAGE TREATMENT
  - MALNUTRITION IS 14% OF GLOBAL BURDEN OF DISEASE (DALYS)
  - SANITATION-RELATED DISEASES 3.4%

- SUB-SAHARAN AFRICA
  - EXCRETA PRODUCTION IS MORE THAN 100% OF THE LOCAL APPLICATION OF MINERAL FERTILISERS

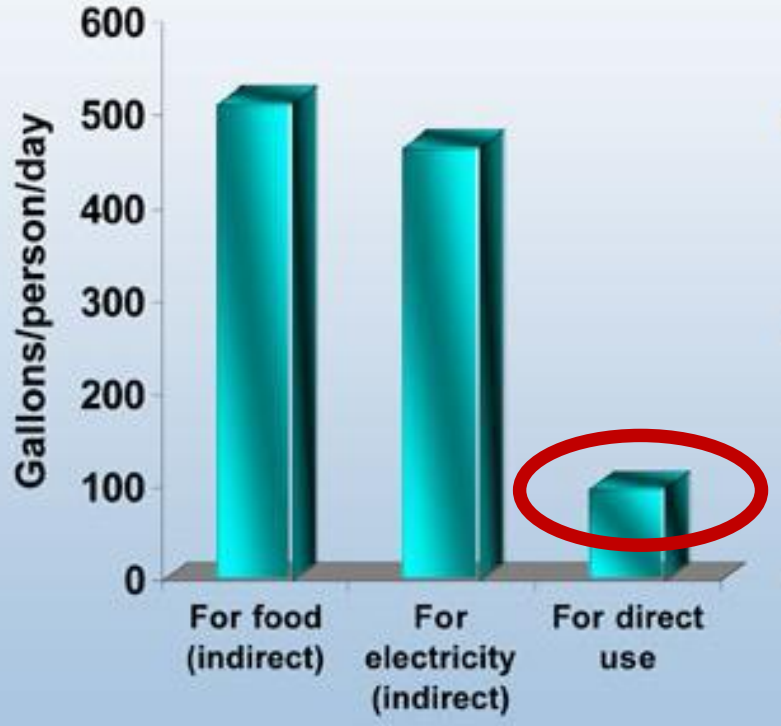
Annika Nordin, Ammonia Sanitisation of Human Excreta Treatment Technology for Production of Fertiliser, Doctoral Thesis, Swedish University of Agricultural Sciences, Uppsala (2010)

Africa – the dark continent?

WATER NEEDS ENERGY



Water used to produce household electricity exceeds direct household water use



GALLONS PER PERSON PER DAY

- 510 for food production
  - includes irrigation and livestock
- 465 to produce household electricity
  - Range: 30 to 600 depending on technology
- 100 direct household use
  - includes bathing, laundry, lawn watering, etc.

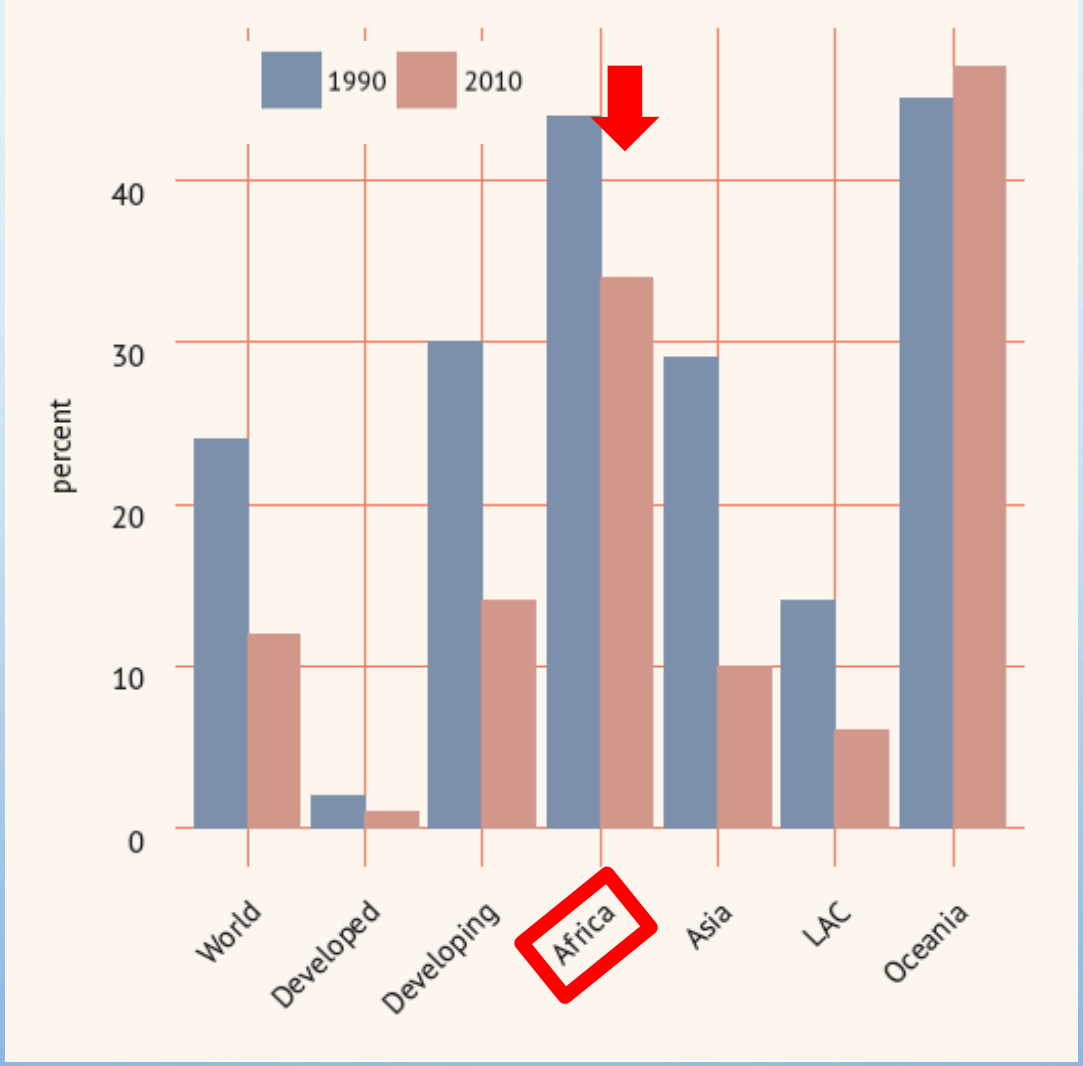
Source: derived from Gleick, P. (2002). *World's Water 2002-2003.*

100 gallons per person per day in Africa?

EAO Energy Analysis Office
Understanding Energy Issues

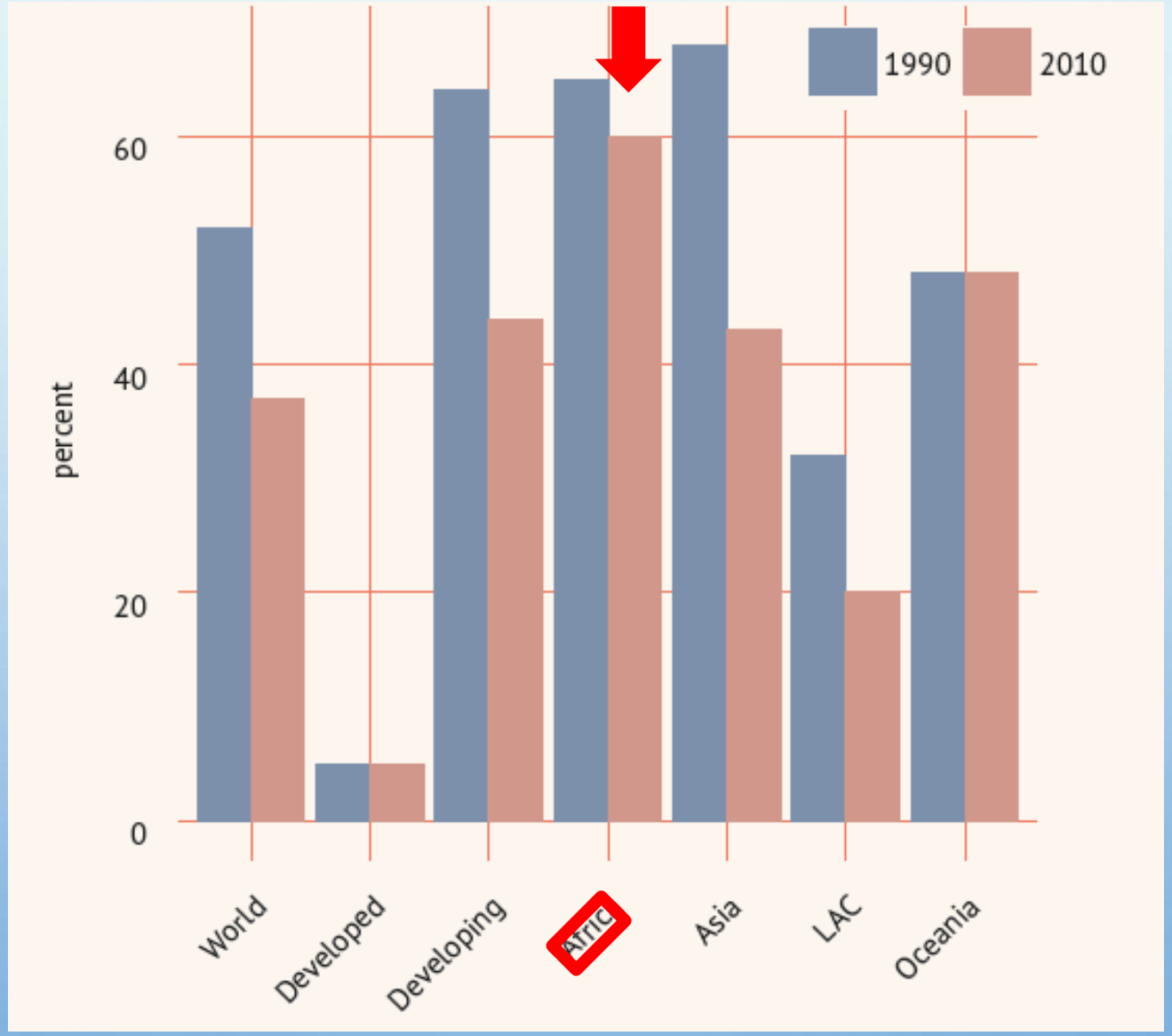
NREL National Renewable Energy Laboratory

POPULATION WITHOUT REASONABLE ACCESS TO IMPROVED WATER SOURCES (2010)



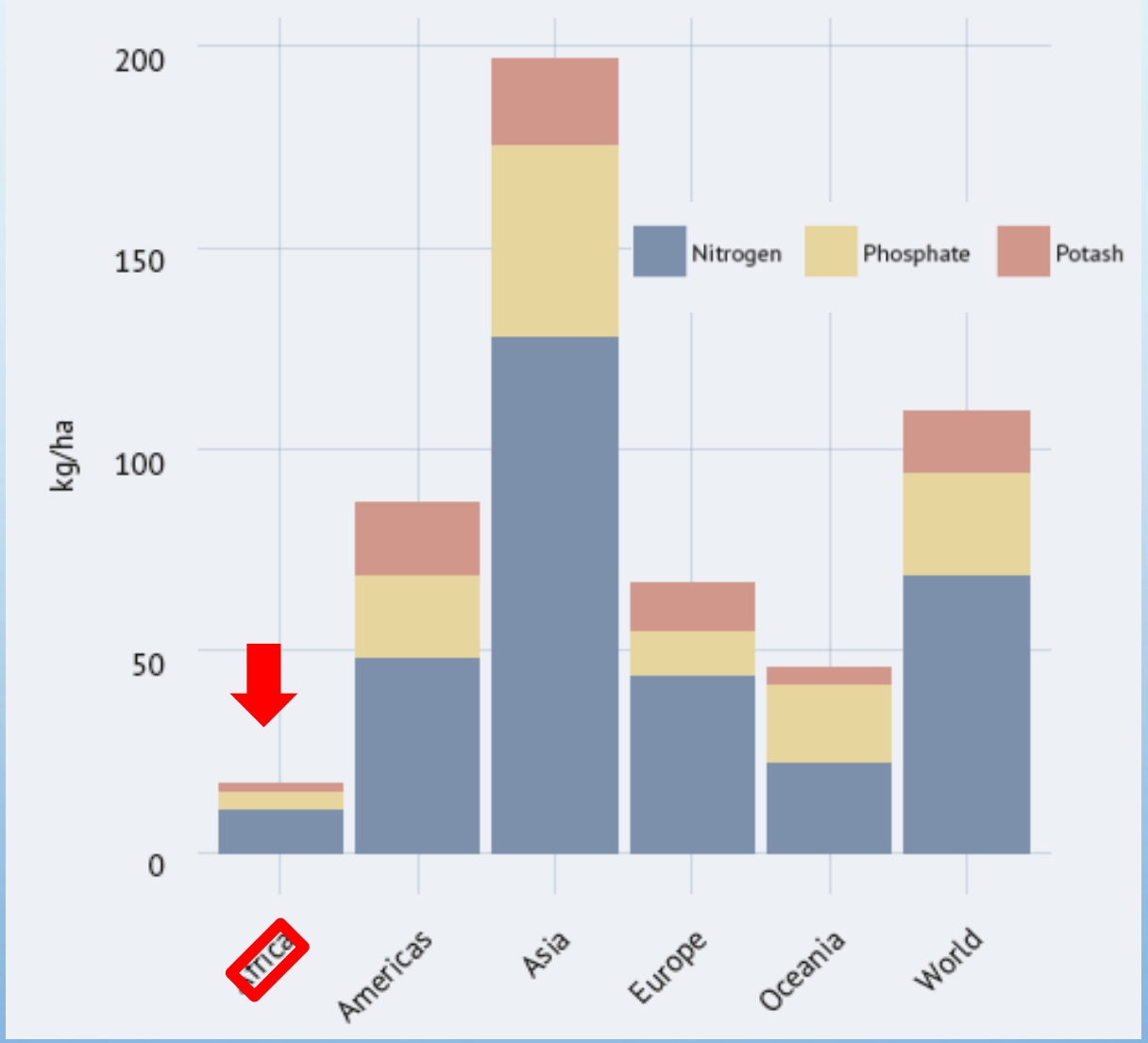
FAO STATISTICAL YEARBOOK, 2013. World Food and Agriculture
http://www.fao.org/docrep/018/i3107e/i3107e00.pdf

POPULATION WITHOUT REASONABLE ACCESS TO IMPROVED SANITATION (2010)



FAO STATISTICAL YEARBOOK, 2013.
World Food and Agriculture
http://www.fao.org/docrep/018/i3107e/i3107e00.pdf

FERTILISER CONSUMPTION PER HA ARABLE LAND



FAO STATISTICAL YEARBOOK, 2013. World Food and Agriculture http://www.fao.org/docrep/018/i3107e/i3107e00.pdf

SOUTH AFRICA - FACTS

- **Area 1,221,037 km²**
- **Population 51,770,560**
- **Density 42.4/km²**
- **Access to an improved water source 91%**
- **Access to improved sanitation 79%**
- **Water scarce country**

(Census 2011)

WATER CHALLENGES

- GROWING GAP BETWEEN WATER SUPPLY AND DEMAND
- WATER SCARCE COUNTRY
  - SEMIARID COUNTRY (LIMITED RAINFALL)
  - LIMITED UNDERGROUND WATER SOURCES
  - RELIANT ON WATER TRANSFERS FROM OTHER NEIGHBOURING COUNTRIES (25% FORM LESOTHO)
- HIGH WATER DEMAND
  - AGRICULTURE
  - INDUSTRIAL (MINING, POWER GENERATION)
  - LARGE AND GROWING URBAN CENTRES

The majority of the overall water demand ~ 15 billion m3

CONVENTIONAL SEWAGE TREATMENT NOT ALWAYS A FEASIBLE OPTION, IT IS TOO EXPENSIVE AND CONSUMES A LOT OF ENERGY!!

EXCRETA FACTS AND FIGURES

	Units	Urine	Faeces	Toilet paper	Black water (urine + faeces)
wet mass	kg/person.y	550	51	8.9	**610**
dry mass	kg/person.y	21	11	8.5	**40**
nitrogen	kg/person.y	4	0.55		**4.5**
phosphorus	kg/person.y	0.36	0.18		**0.55**

Vinnerås et al. 2006

most pathogens are in the faeces

most nutrients are in the urine

EXCRETA PLUS FLUSH WATER

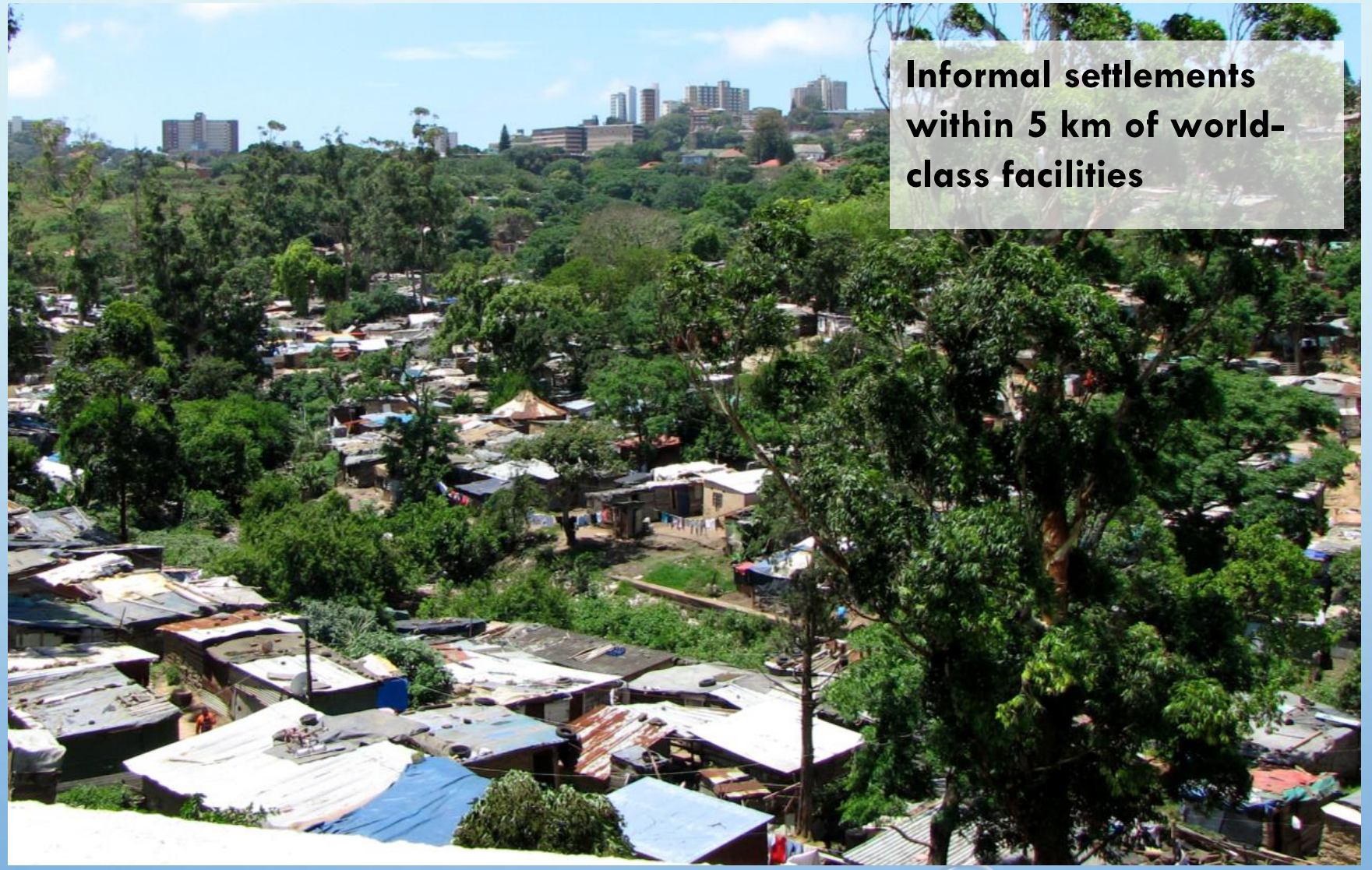
	Units	Black water (urine + faeces)	Black water + Flush water
wet mass	kg/person.y	**610** →	**18,000**
dry mass	kg/person.y	40	**40**
nitrogen	kg/person.y	4.5	**4.5**
phosphorus	kg/person.y	0.5	**0.5**

all pathogens are in the water!

Durban: City of contrasts

- Second largest industrial hub
- Fastest growing urban area
- Major tourist destination
- South Africa's major port

Durban: City of contrasts



DURBAN IN CONTEXT

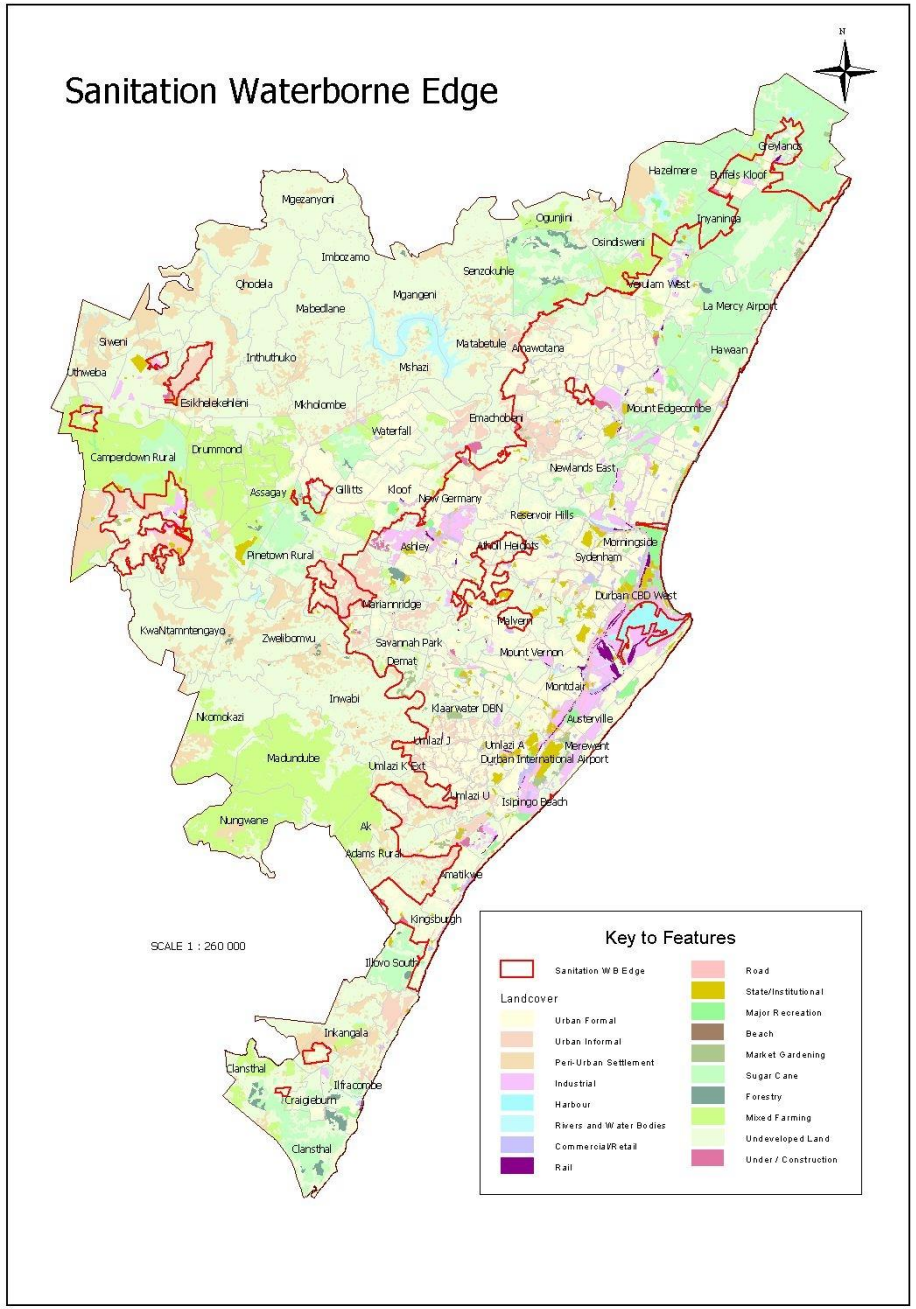
- A CITY OF 3,7 MILLION PEOPLE, UP FROM 3,0 MILLION IN 2001
- HIGH LEVELS OF POVERTY:
  - 40% OF RESIDENTS EARNING LESS THAN US$ 2 A DAY
  - UNEMPLOYMENT LEVELS OF ABOUT 30%
- RAPID URBANISATION AND AN INWARD MIGRATION OF PEOPLE
- THE CITY OF '*THREE ONE MILLIONS*' IN 2000

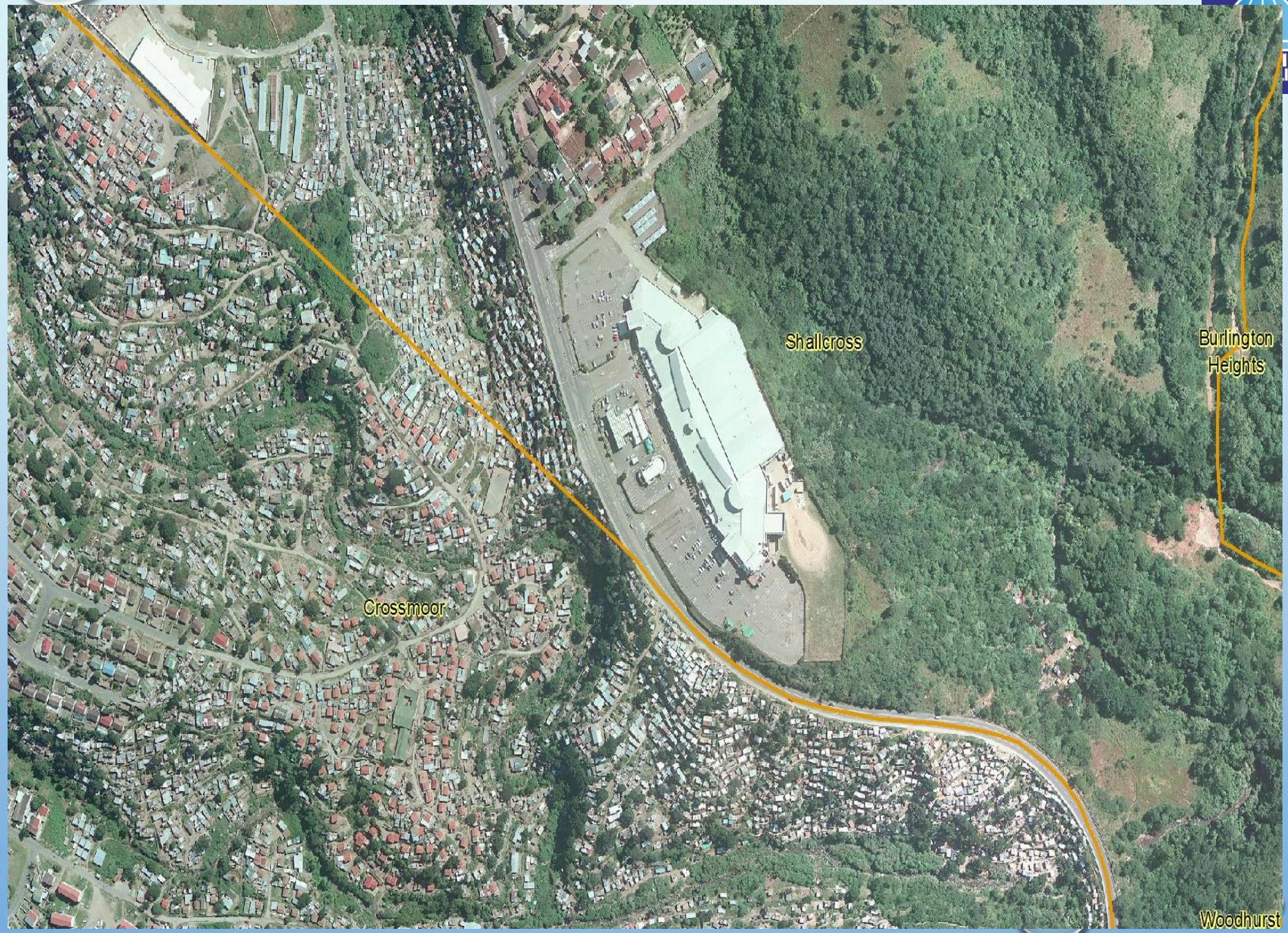
THE THREE ‘ONE MILLIONS’

- THE WATER AND SANITATION CHALLENGES THAT WE FACED IN DURBAN IN 2000 WERE HUGE:
  - WHILE… 1 MILLION PEOPLE HAD ‘FIRST WORLD’ SERVICES…
  - 1 MILLION PEOPLE WITH SEVERELY RUN DOWN SERVICES (POORLY MAINTAINED/FAILING)
  - 1 MILLION PEOPLE WITHOUT MUNICIPAL WATER AND SANITATION SERVICES
- INWARD MIGRATION TO THE METRO AREA HAS CONTINUED AT A HIGH RATE AND HAS ADDED 700,000 PEOPLE IN 12 YEARS

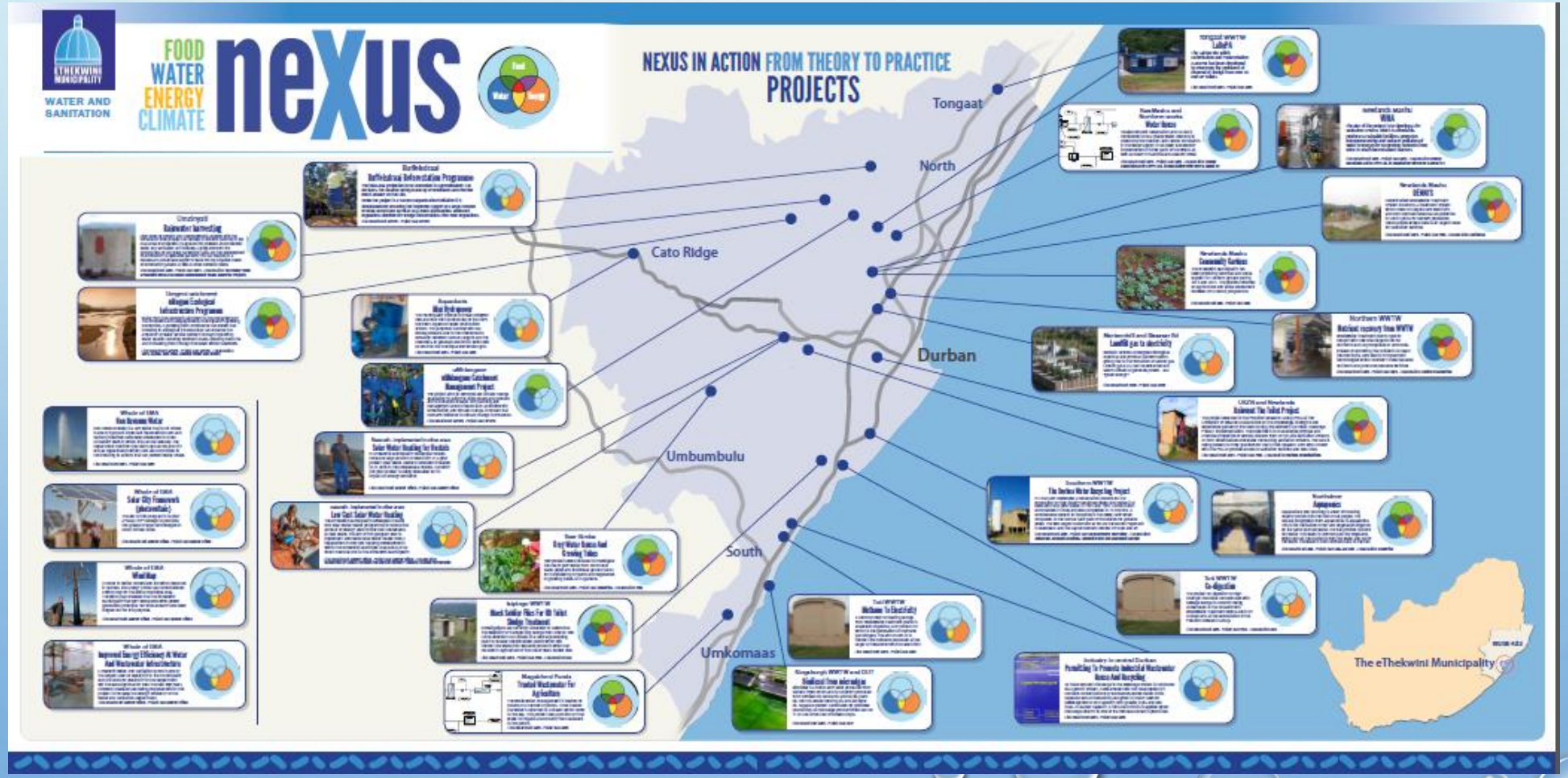
THE SANITATION EDGE

- Providing sewerage to the 250 000 families not connected to piped network in Durban would cost > USD 4 billion …and is not affordable
- The policy adopted defined a *sanitation edge* within which development densities were high enough to make affordable piped sewers connected to centralised STPs
- Outside the urban edge, off-grid/onsite sanitation options have been provided (~ USD 65 million)
- Urban slums are too dense to permit one toilet per house that can be accessed, emptied and allow for safe disposal of greywater and blackwater




Shallcross
Burlington Heights
Crossmoor
Woodhurst

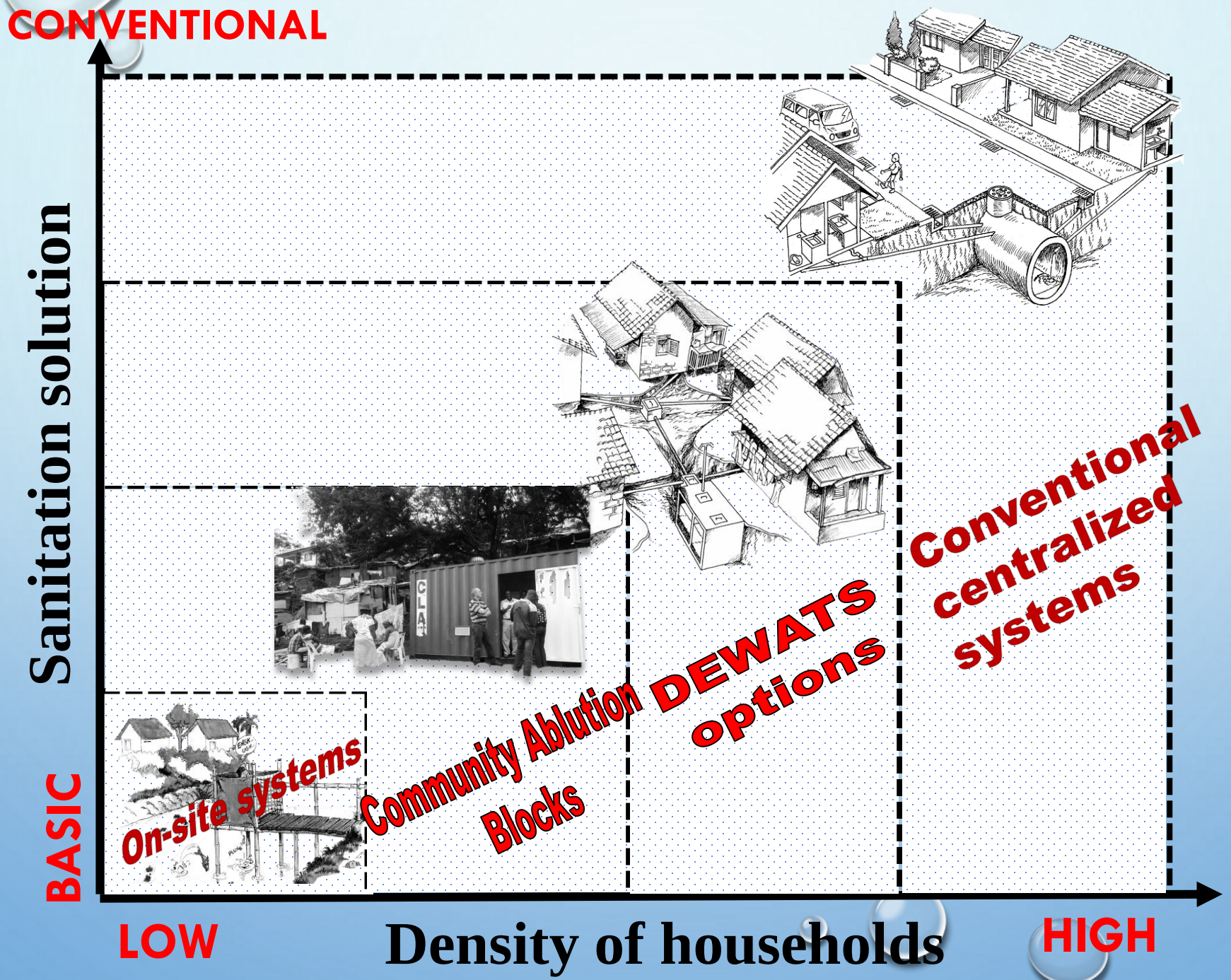
THE MUNICIPALITY



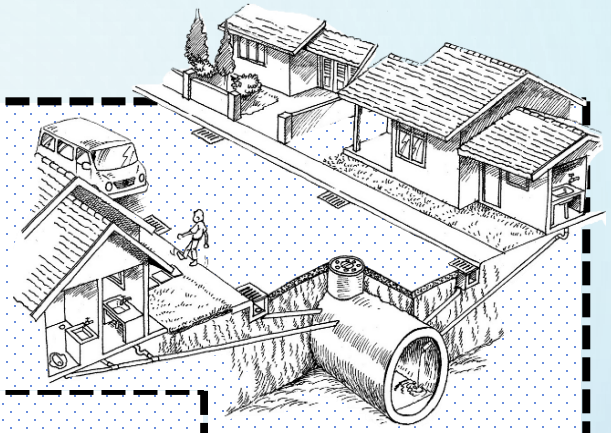
SANITATION PRINCIPLES

(IN BRIEF)

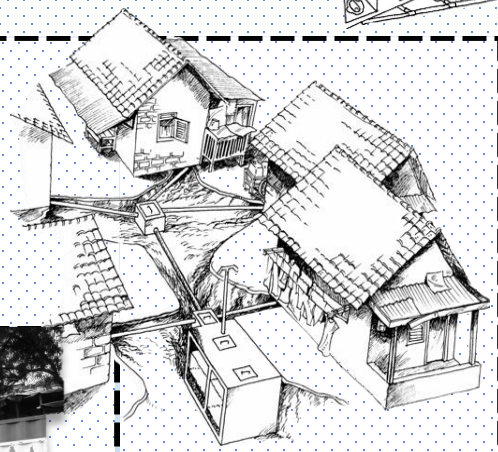
- PUBLIC HEALTH IS THE OBJECTIVE
- SANITATION SYSTEM IN HARMONY WITH WATER SUPPLY
- ALL WATER TO BE ADSORBED ON-SITE UNLESS FORMAL SEWERS PROVIDED


CONVENTIONAL
Sanitation solution
BASIC
LOW
Density of households
HIGH
On-site systems
Community Ablution Blocks
DEWATS options
Conventional centralized systems

EXPENSIVE!



Cost



Conventional centralized systems

DEWATS options

Community Ablution Blocks

On-site systems

CHEAP

LOW

Density of households

HIGH

Current Situation – eThekwini

- 1 mil people in informal settlements and townships
- 35 000 VIPs
  - Need regular emptying
  - Entrepreneurs empty pits safely
  - LaDePa – dry, pasteurised pellets
- 80 000 UDDTs
  - BSF treatment
- 360 Community Ablution Blocks
  - central area – sewered or VIP
- DEWATS
- Conventional sewer

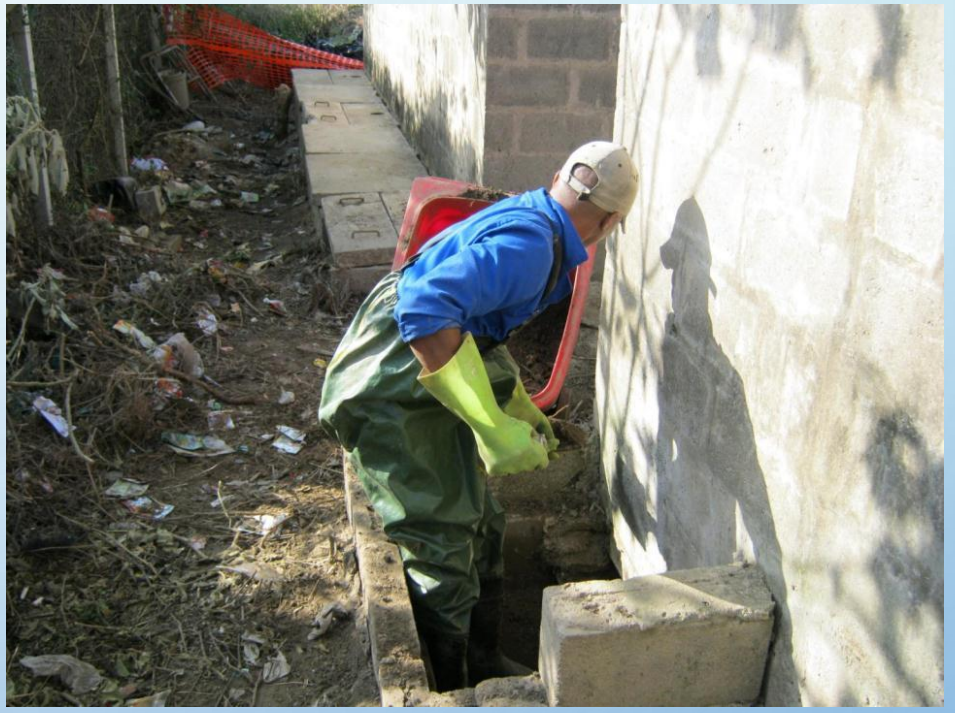
POLLUTION RESEARCH GROUP – PRIMARY ACTIVITIES

- CONTRACT RESEARCH
- EXTENSIVE BACKGROUND IN THE WASH FIELD
- CUSTOMER FOCUSED
- POST GRADUATE STUDENTS
- FUNDING
  - ETHEKWINI MUNICIPALITY
  - WATER RESEARCH COMMISSION
  - BILL & MELINDA GATES FOUNDATION
  - BORDA (INGO)
- WIDE COLLABORATION
  - HEALTH, SCIENCE, AGRICULTURE, SOCIAL SCIENCE, ENGINEERING

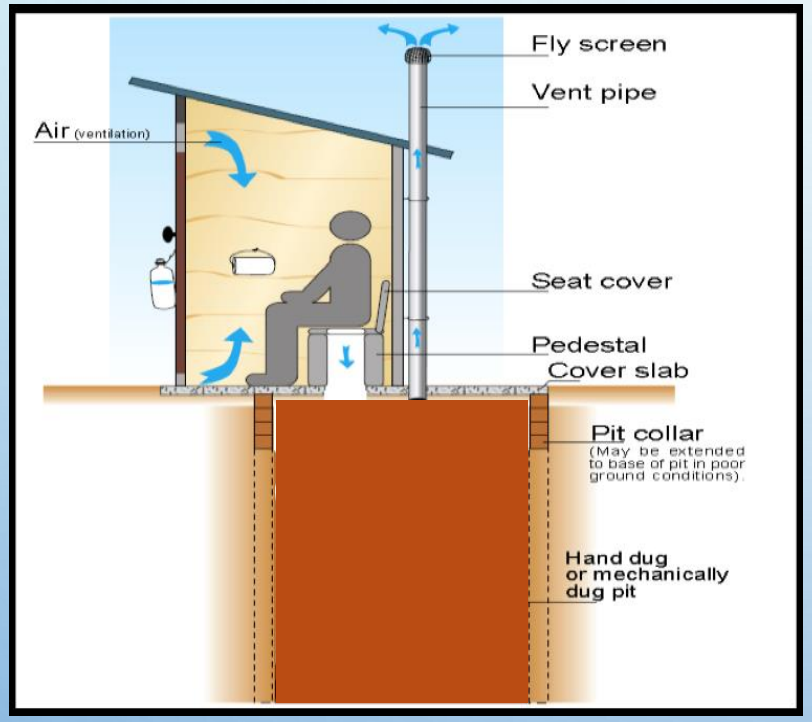
FACILITIES AND ACTIVITIES OFFERED BY THE PRG TO SUPPORT FAECAL SLUDGE RESEARCH

- ACCESS TO DIFFERENT SANITATION SYSTEMS
- SANITATION (REFERENCE) LABORATORY
- MECHANICAL WORKSHOP
- FIELD TESTING
- SYSTEMS AND PROTOTYPES TESTING
- TRAINING AND SHARING

VIPs



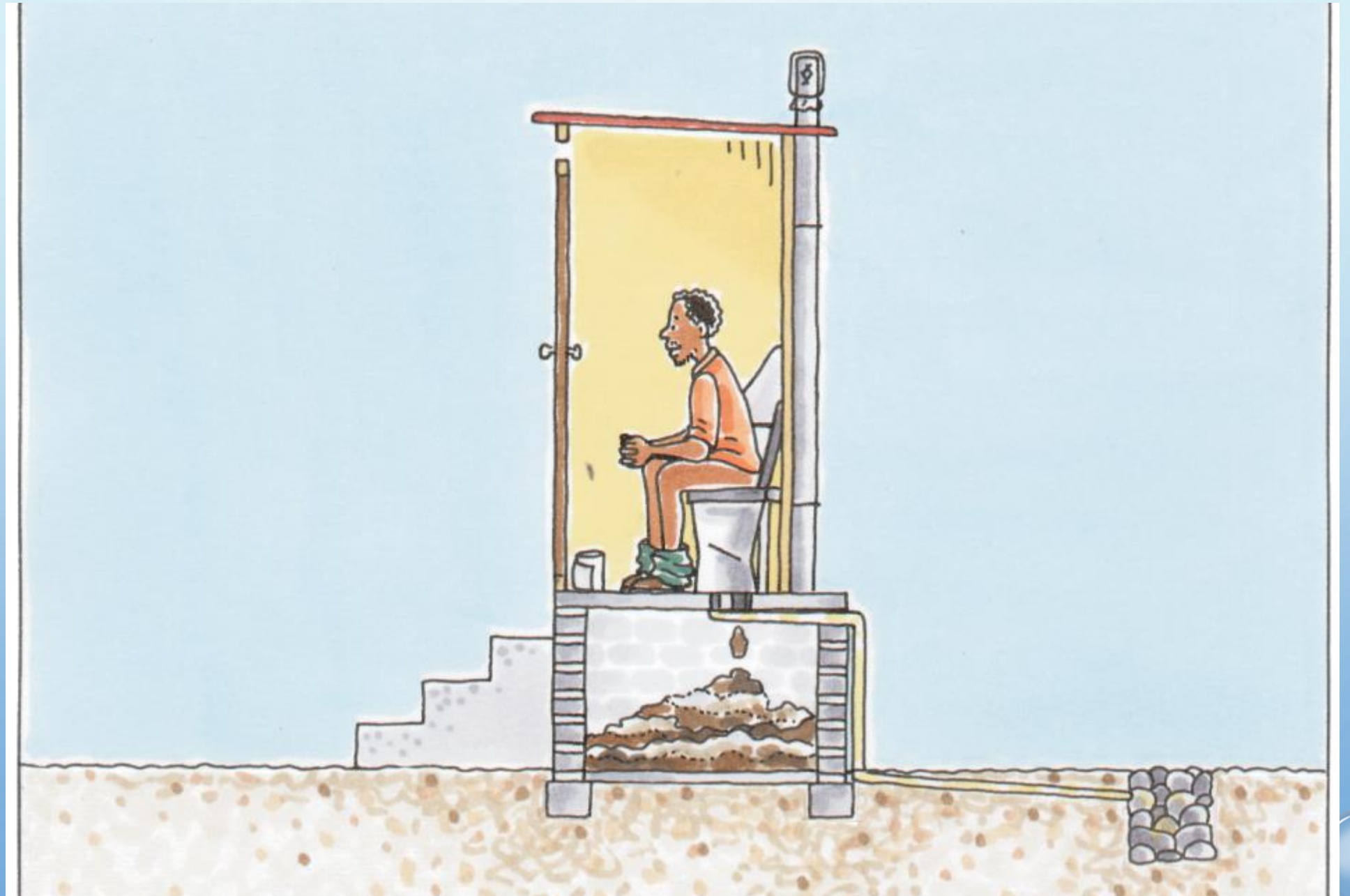
PIT EMPTYING



COMMUNITY ABLUTION BLOCKS

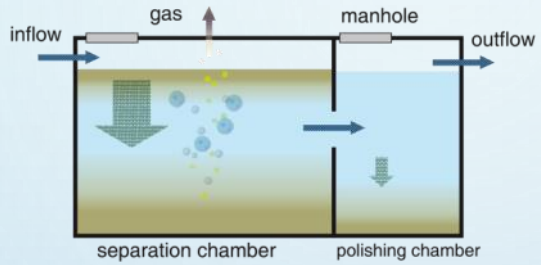
URINE DIVERSION TOILETS

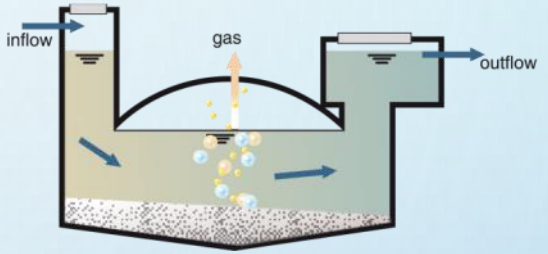
URINE DIVERSION TOILET



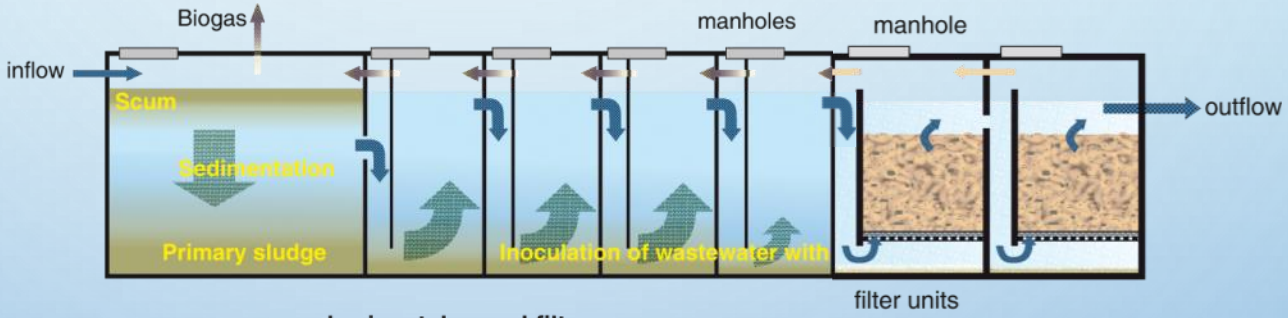
Decentralised Wastewater Treatment Systems

Sedimentation

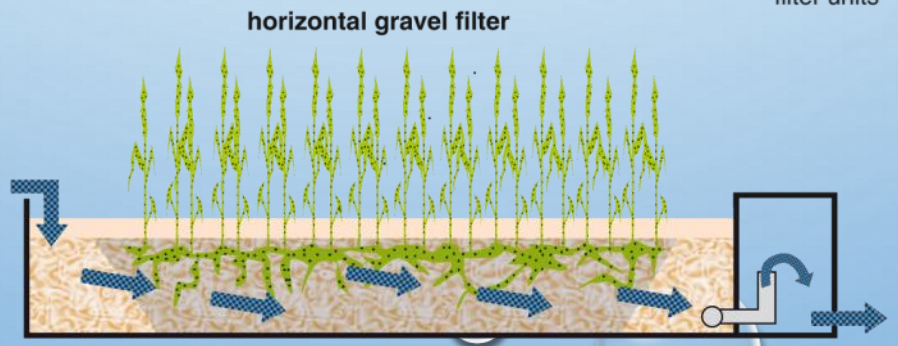




Anaerobic digestion



Aerobic and facultative decomposition



No energy input, low skill requirements for O&M,
Modular and partly standardized

POLLUTION RESEARCH GROUP – PRIMARY ACTIVITIES

- CONTRACT RESEARCH
- EXTENSIVE BACKGROUND IN THE WASH FIELD
- CUSTOMER FOCUSED
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- TRAINING AND SHARING

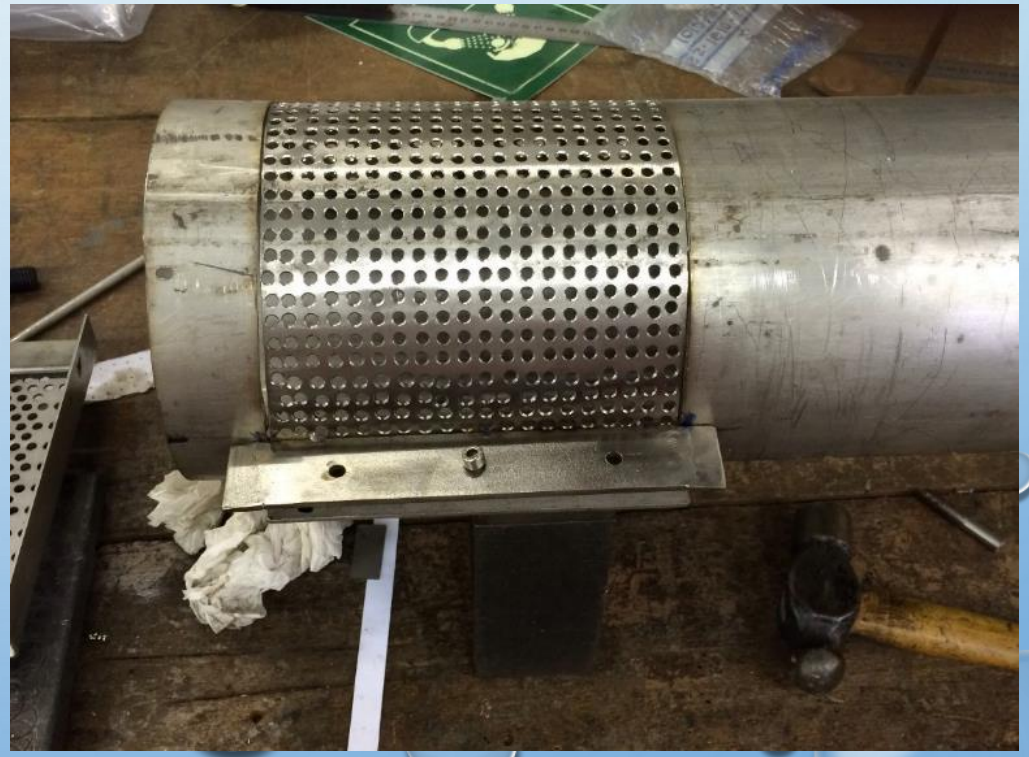
SPECIALISED SANITATION LABORATORY

MECHANICAL WORKSHOP

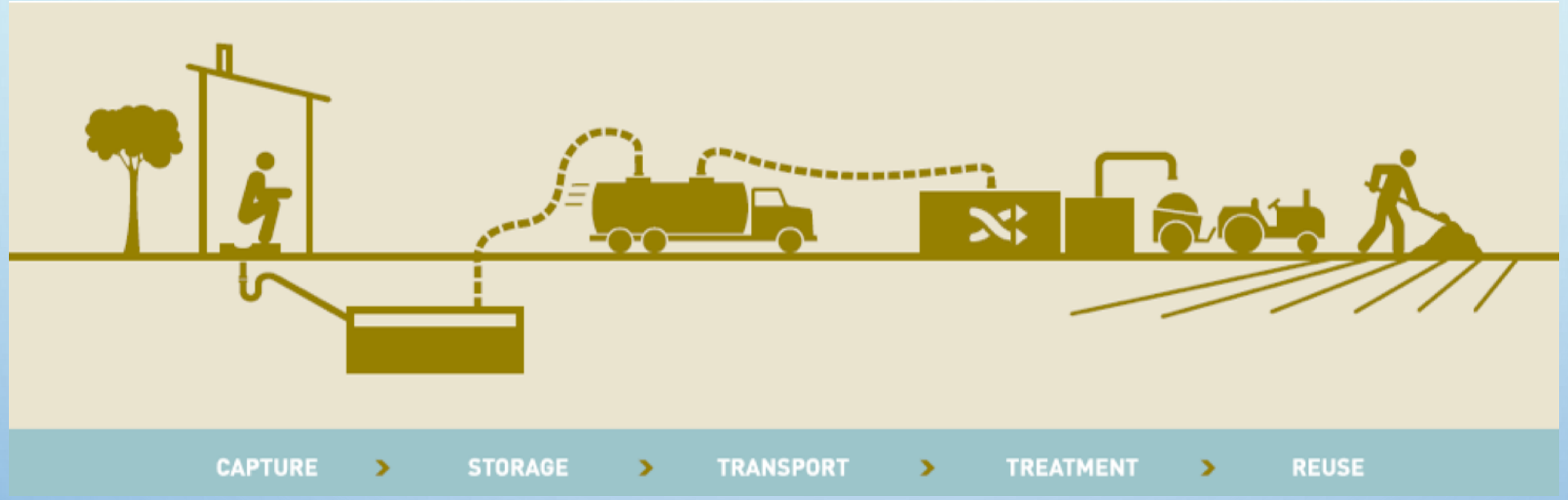
- EQUIPMENT CONSTRUCTION
- MODIFICATION

Viscous heater

Hydraulic ram



REINVENT THE TOILET CHALLENGE
Bill & Melinda Gates Foundation



INTERACTIONS WITH OTHER ORGANISATIONS - PROVISION OF DATA, HOSTING VISITORS, ASSISTANCE ON RESEARCH PROJECTS, TESTING OF PROTOTYPES AND EXCHANGE OF INFORMATION

- AGRI PROTEIN (SOUTH AFRICA)
- ASIAN INSTITUTE OF TECHNOLOGY (THAILAND)
- BANGLADESH UNIVERSITY OF ENGINEERING & TECHNOLOGY (BUET)
- BATH UNIVERSITY (UK)
- BEAUMONT (USA)
- BILL & MELINDA GATES FOUNDATION
- BORDA
- BRISTOL ROBOTICS LAB (UK)
- CALIFORNIA POLYTECHNIC UNIVERSITY (USA)
- CENTRE OF SCIENCE AND ENVIRONMENT (INDIA)
- CLIMATE FOUNDATION (USA)
- CRANFIELD UNIVERSITY (UK)
- DUKE UNIVERSITY (USA)
- EAWAG (SWITZERLAND)
- ETHEKWINI WATER AND SANITATION (SOUTH AFRICA)
- FIRMENICH (SWITZERLAND)
- INRA (FRANCE)
- JANICKI INDUSTRIES (USA)
- LOUGHBOROUGH UNIVERSITY (UK)
- MOTT MACDONALD (UK)
- NORTH CAROLINA STATE UNIVERSITY (USA)
- NORTH-WEST UNIVERSITY, UNIT FOR ENVIRONMENTAL SCIENCE AND MANAGEMENT, POTCHEFSTROOM CAMPUS
- OKLAHOMA STATE UNIVERSITY (USA)
- PLYMOUTH MARINE LABORATORY (UK)
- RESEARCH TRIANGLE INSTITUTE (USA)
- SAN DIEGO STATE UNIVERSITY (USA)
- SANERGY (KENYA)
- STOCKHOLM ENVIRONMENT INSTITUTE
- SWEDISH UNIVERSITY OF AGRICULTURAL SCIENCES
- SYNAPSE
- TECHNICAL UNIVERSITY OF DELFT (TU DELFT, NETHERLANDS)
- UNESCO-IHE (NETHERLANDS)
- UNILEVER (UK)
- UNIVERSITÉ LAVAL (CANADA)
- UNIVERSITY COLLEGE, LONDON (UK)
- UNIVERSITY OF COLORADO (USA)
- UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN
- UNIVERSITY OF KWAZULU-NATAL
- UNIVERSITY OF TORONTO (CANADA)

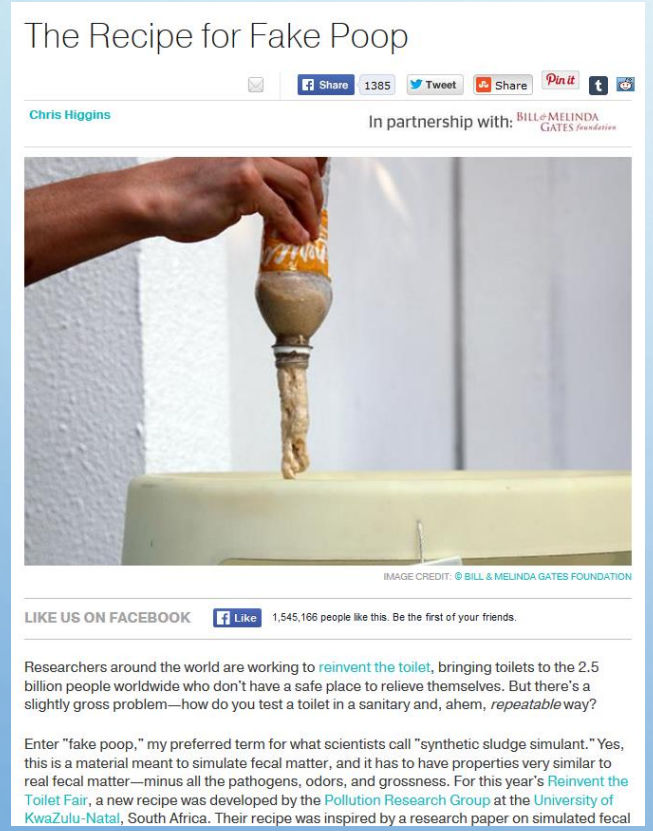
AFRICAN ORGANISATIONS

- KHANYISA PROJECTS
- PARTNERS IN DEVELOPMENT (PID)
- AFRICAN MUNICIPALITIES
- BOTSWANA GOVERNMENT
- JIMMA UNIVERSITY, ETHIOPIA
- EGERTON UNIVERSITY, KENYA
- MAKERERE UNIVERSITY, UGANDA
- UNIVERSITY, OF MALAWI, MALAWI
- UNIVERSITY OF ZAMBIA, ZAMBIA
- UNIVERSITY OF BOTSWANA, BOTSWANA
- WATER FOR PEOPLE, UGANDA
- MZUZU UNIVERSITY, MALAWI
- RHODES UNIVERSITY, RSA
- INTERNATIONAL INSTITUTE FOR WATER & ENVIRONMENTAL ENGINEERING (2IE), BURKINA FASO

REINVENT THE TOILET FAIR: INDIA 2013

DEVELOPMENT OF FS SIMULANTS

- TOILET FAIR INDIA 2013



The Recipe for Fake Poop

Share 1385 Tweet Share Pin it

Chris Higgins

In partnership with: BILL & MELINDA GATES foundation

IMAGE CREDIT: © BILL & MELINDA GATES FOUNDATION

LIKE US ON FACEBOOK Like 1,545,166 people like this. Be the first of your friends.

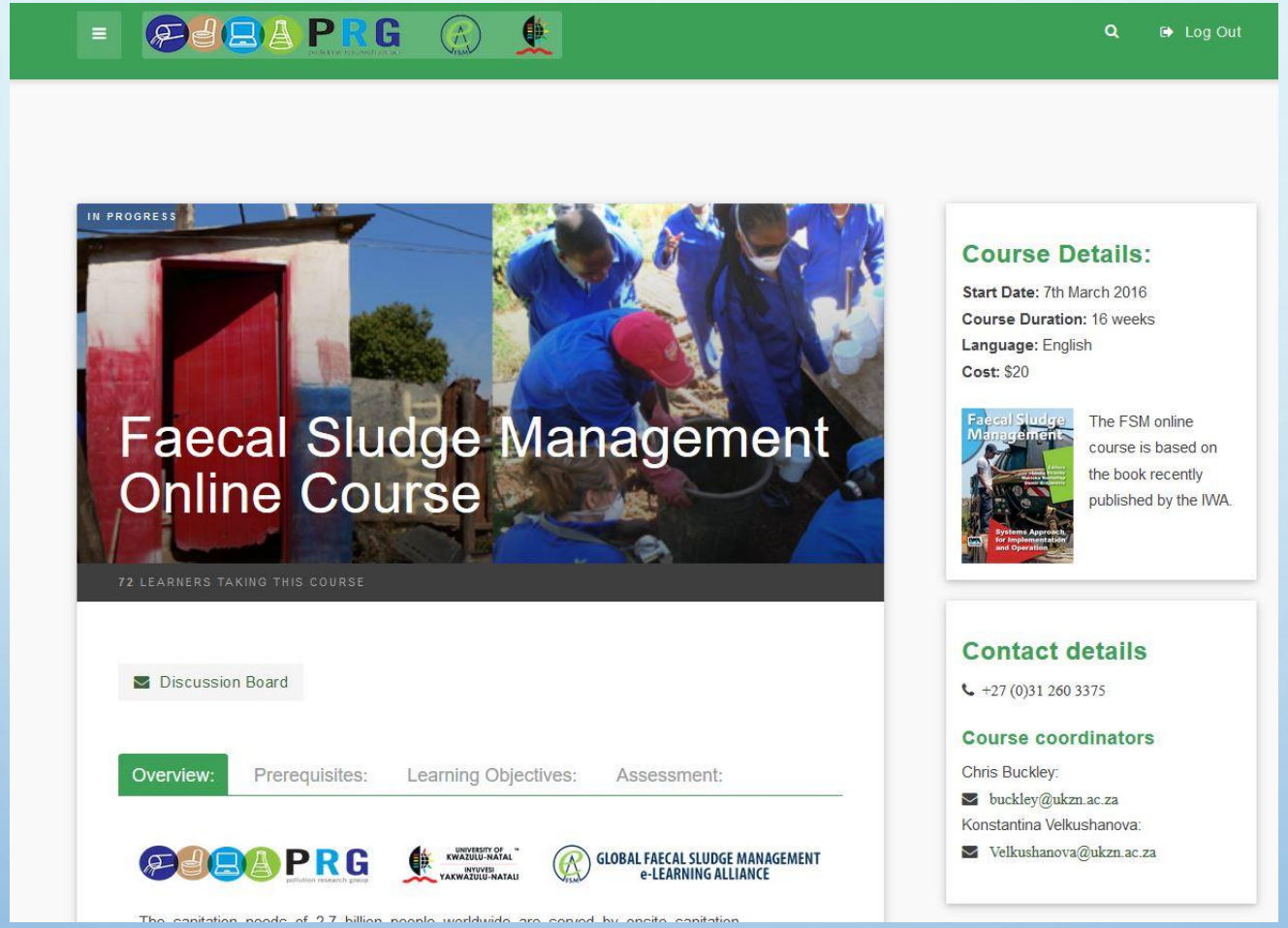
Researchers around the world are working to reinvent the toilet, bringing toilets to the 2.5 billion people worldwide who don't have a safe place to relieve themselves. But there's a slightly gross problem—how do you test a toilet in a sanitary and, ahem, *repeatable* way?

Enter "fake poop," my preferred term for what scientists call "synthetic sludge simulant." Yes, this is a material meant to simulate fecal matter, and it has to have properties very similar to real fecal matter—minus all the pathogens, odors, and grossness. For this year's Reinvent the Toilet Fair, a new recipe was developed by the Pollution Research Group at the University of KwaZulu-Natal, South Africa. Their recipe was inspired by a research paper on simulated fecal

http://mentalfloss.com/article/56003/recipe-fake-poop

Radford, JT; Underdown, C; Velkushanova, K; Byrne, A; Smith, DPK; Fenner, RA; Pietrovito, J; Whitesell, A;
"Faecal sludge simulants to aid the development of desludging technologies" Journal of Water, Sanitation and Hygiene for Development",5,3,456-464,2015,IWA Publishing

FSM ONLINE COURSE



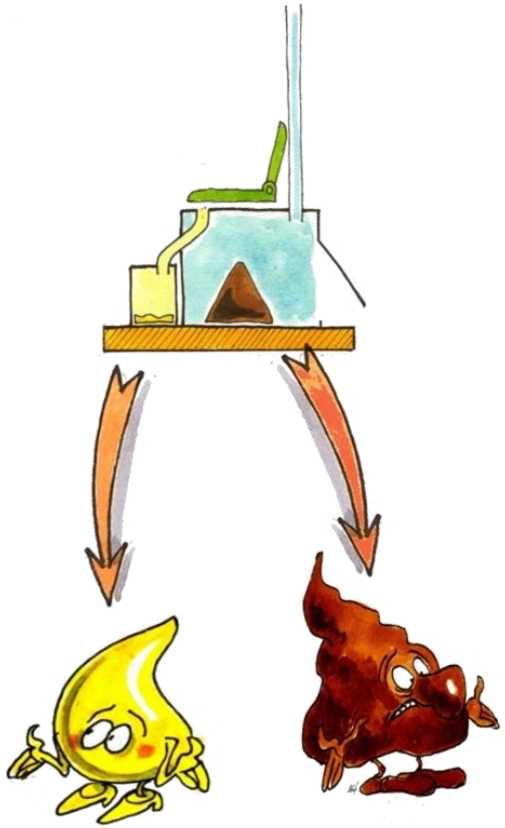
https://prg-durban.org.za/course/faecal-sludge-management

TREATMENT PROCESS OF HUMAN EXCRETA

DR. SANTIAGO SEPTIEN STRINGEL

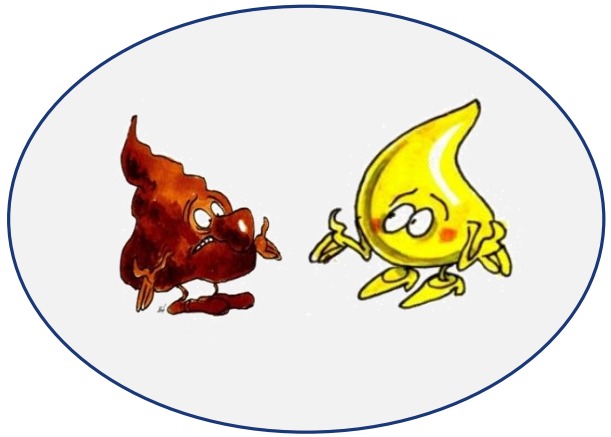
TYPES OF EXCRETA

With separation at the source



Urine **Faeces**

Without separation



Faeces + Urine

Additives

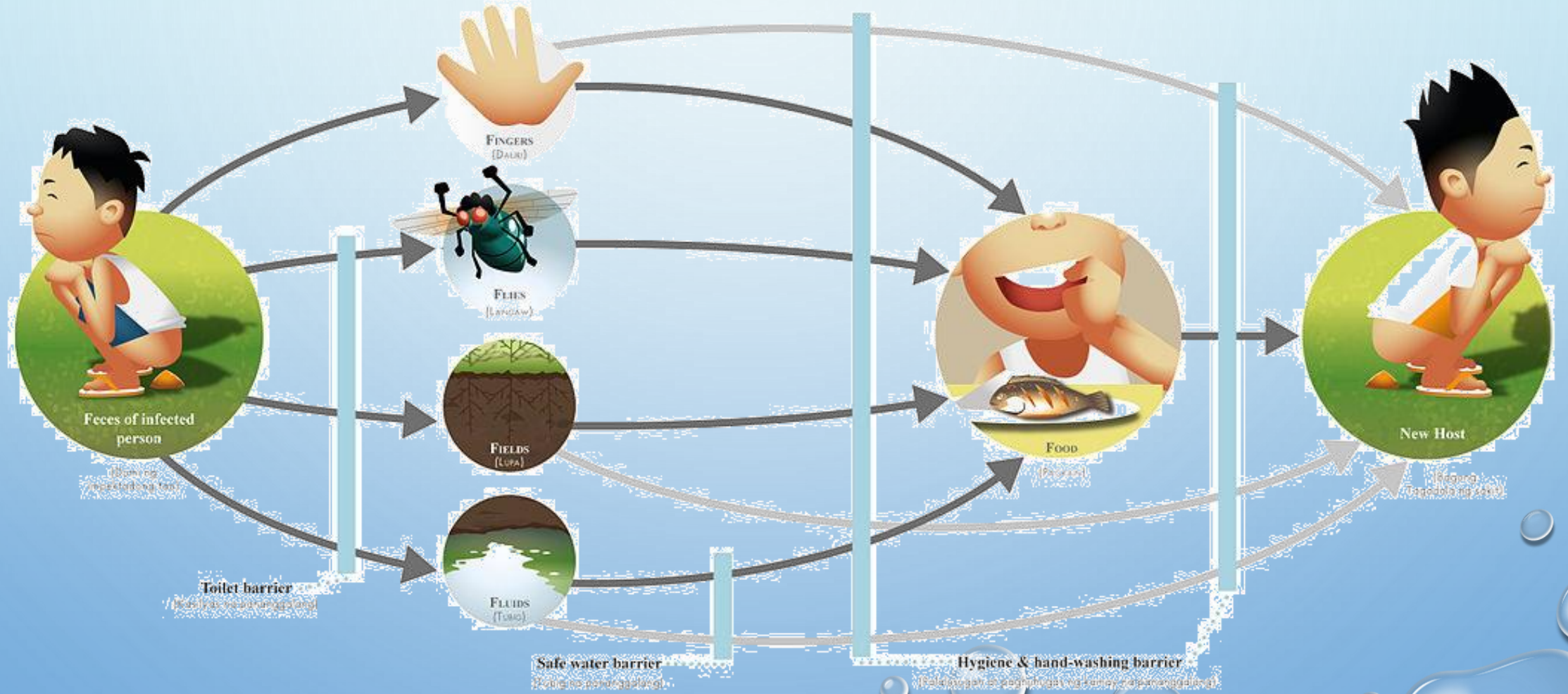
Faeces + Urine + Water

Trash

TREATMENT NECESSARY!

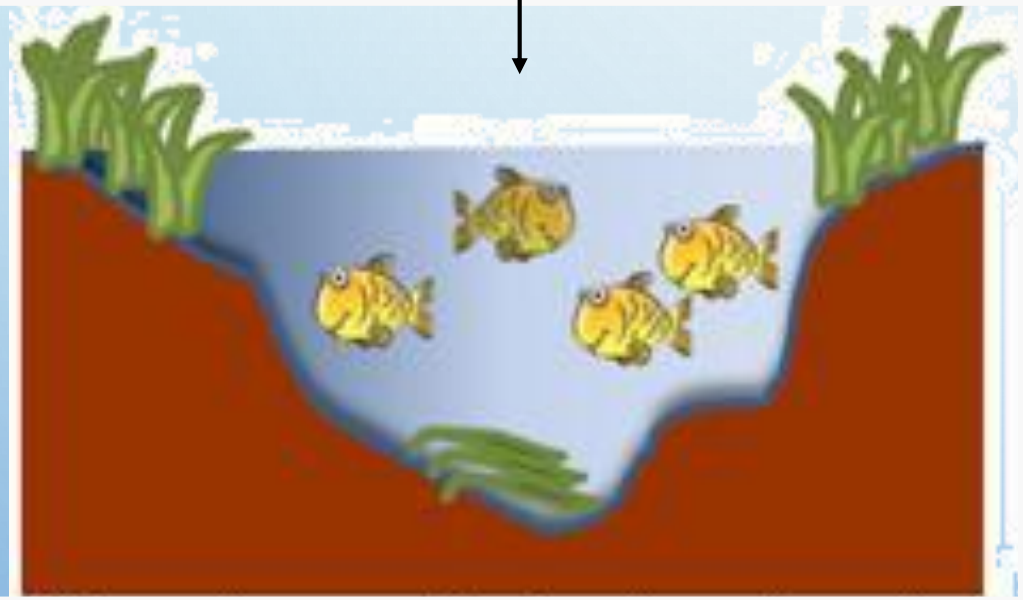
Process

PUBLIC HEALTH RISK



ENVIRONMENTAL RISK – EUTROPHICATION

Nutrients (particularly from urine)



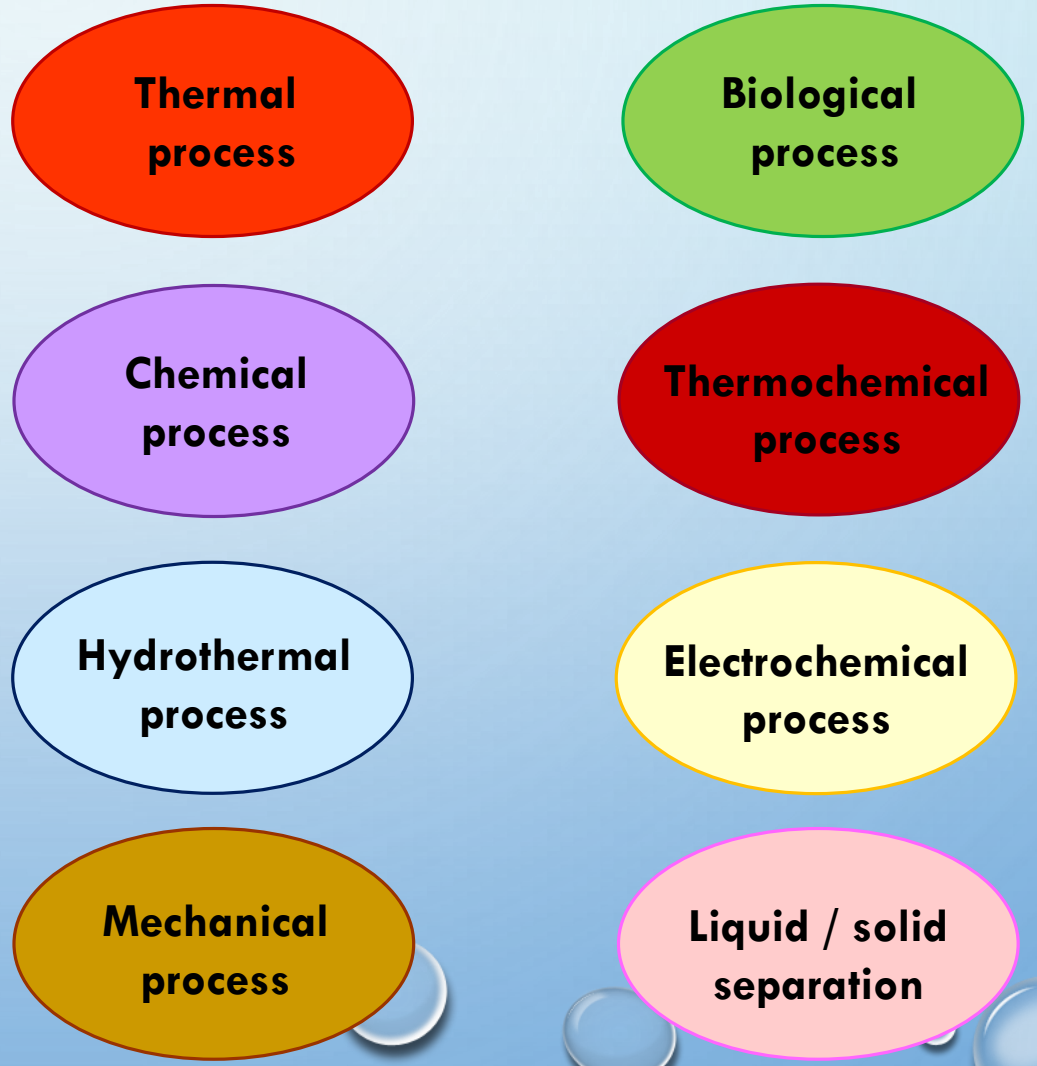

BEFORE
AFTER

TREATMENT NECESSARY!

Process

TYPES OF TREATMENT - MULTIDISCIPLINARY

- ✓ Water treatment
- ✓ Wastewater treatment
- ✓ Sewage sludge treatment
- ✓ Sea water desalination
- ✓ Solid waste treatment
- ✓ Manure treatment
- ✓ Food industry
- ✓ Construction industry
- ✓ Mine industry
- ✓ Energy sector




And the innovation continues….

TREATMENT NECESSARY!

Process

RESOURCE RECOVERY – REUSE WATER

- Irrigation
- Flushing
- Cleaning
- DRINKING!!!

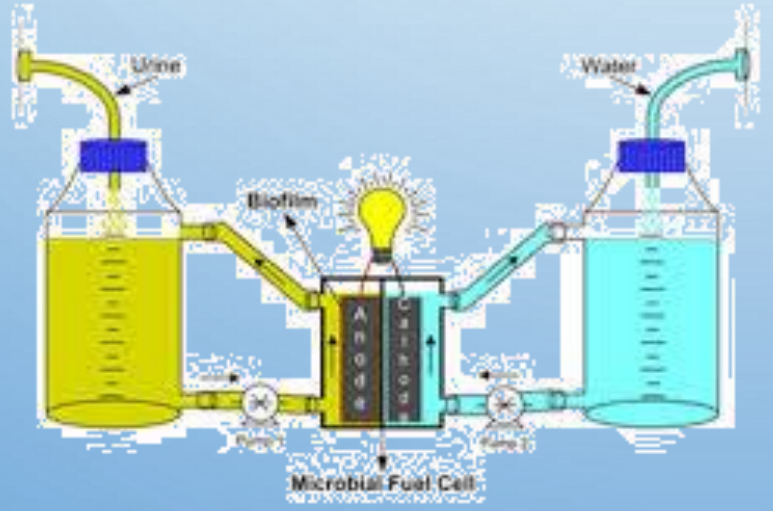
RESOURCE RECOVERY – AGRICULTURE

- Fertilizer
- Soil improver

RESOURCE RECOVERY – FARM

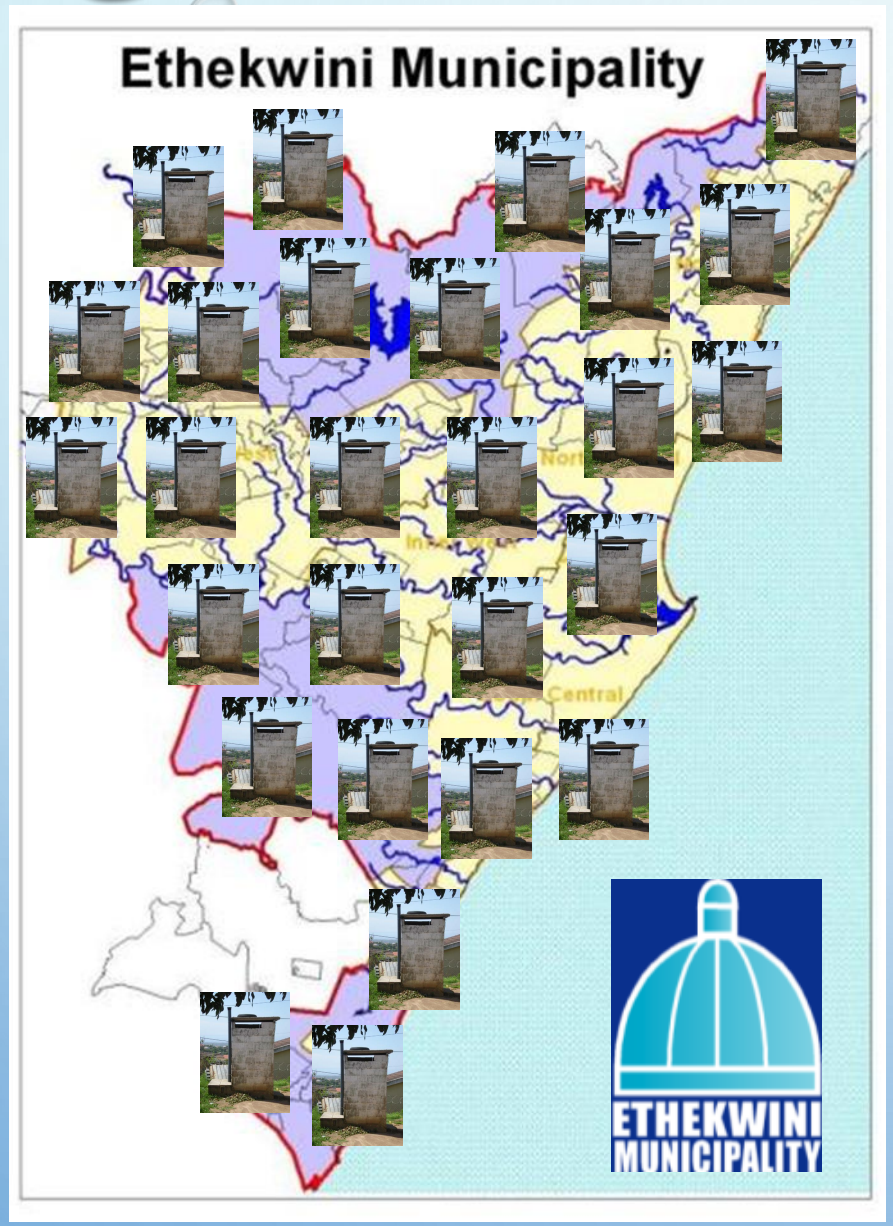
- Fodder
- Protein

RESOURCE RECOVERY – ENERGY



- Heat
- Biochar
- Electricity
- Biodiesel

BENEFITS OF TREATMENT



30,000 Ventilated Improved Pit (VIP) latrines

~ 12,000 M^3 / YEAR OF FAECAL SLUDGE TO TREAT

LaDePa

LATRINE DEHYDRATION PASTEURIZATION

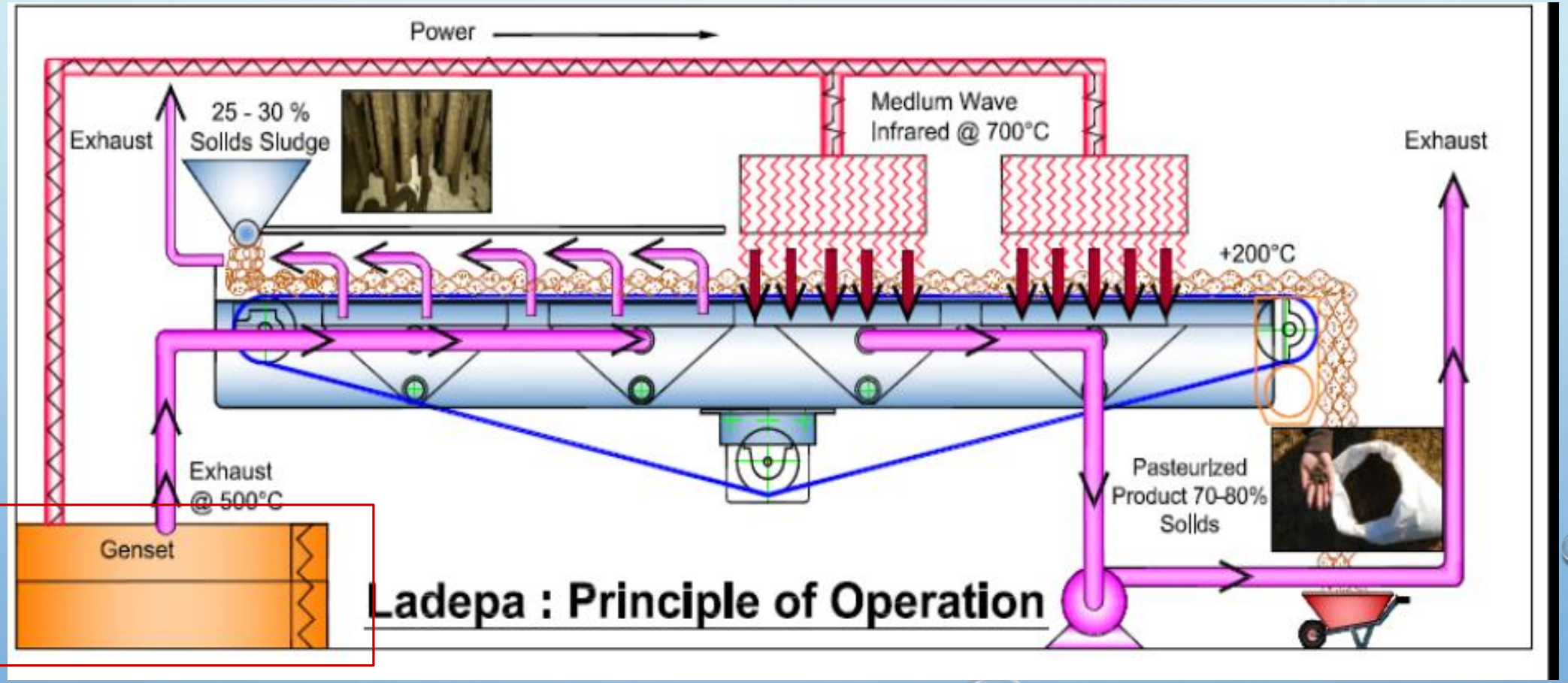
Reduction of mass and volume

Pasteurization

SAFE

Low moisture + high carbon content

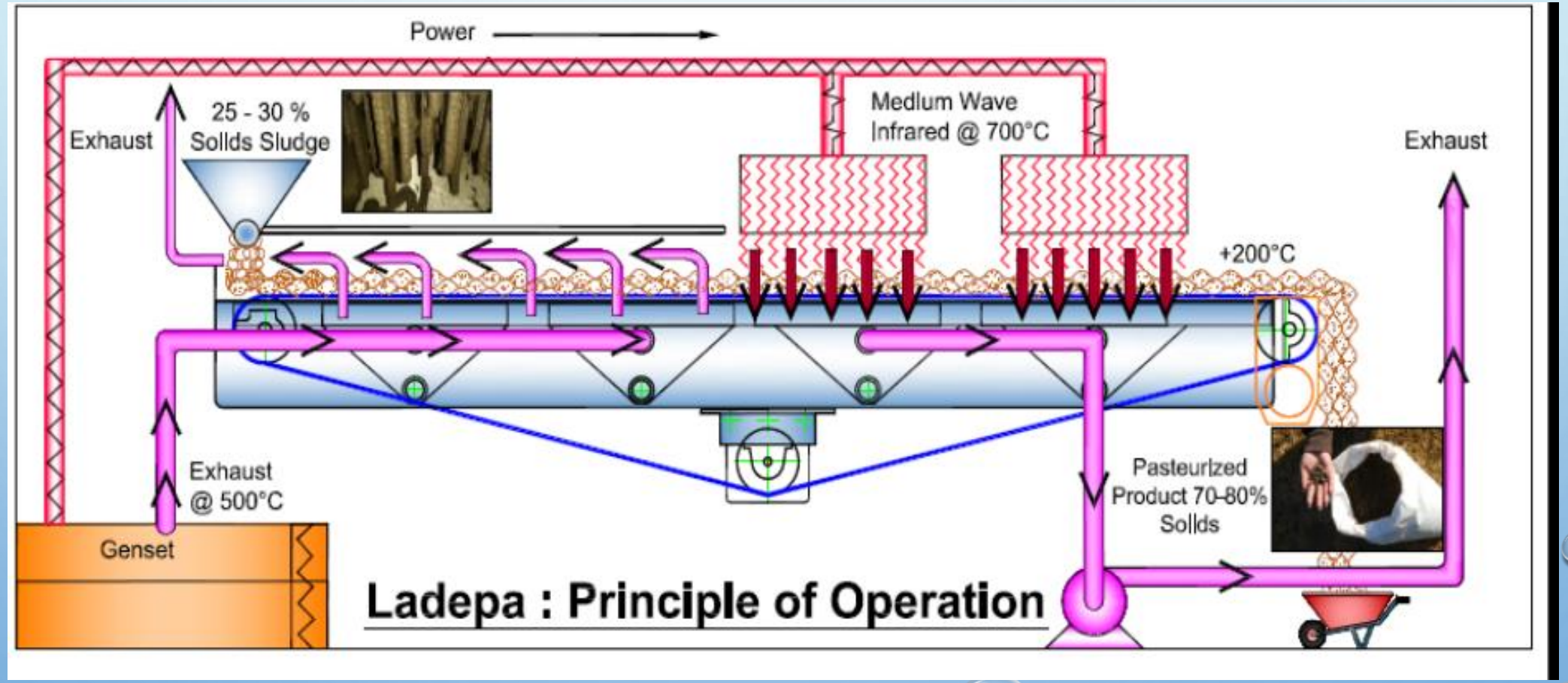
POWER ON



Diesel generator (heat + electricity)

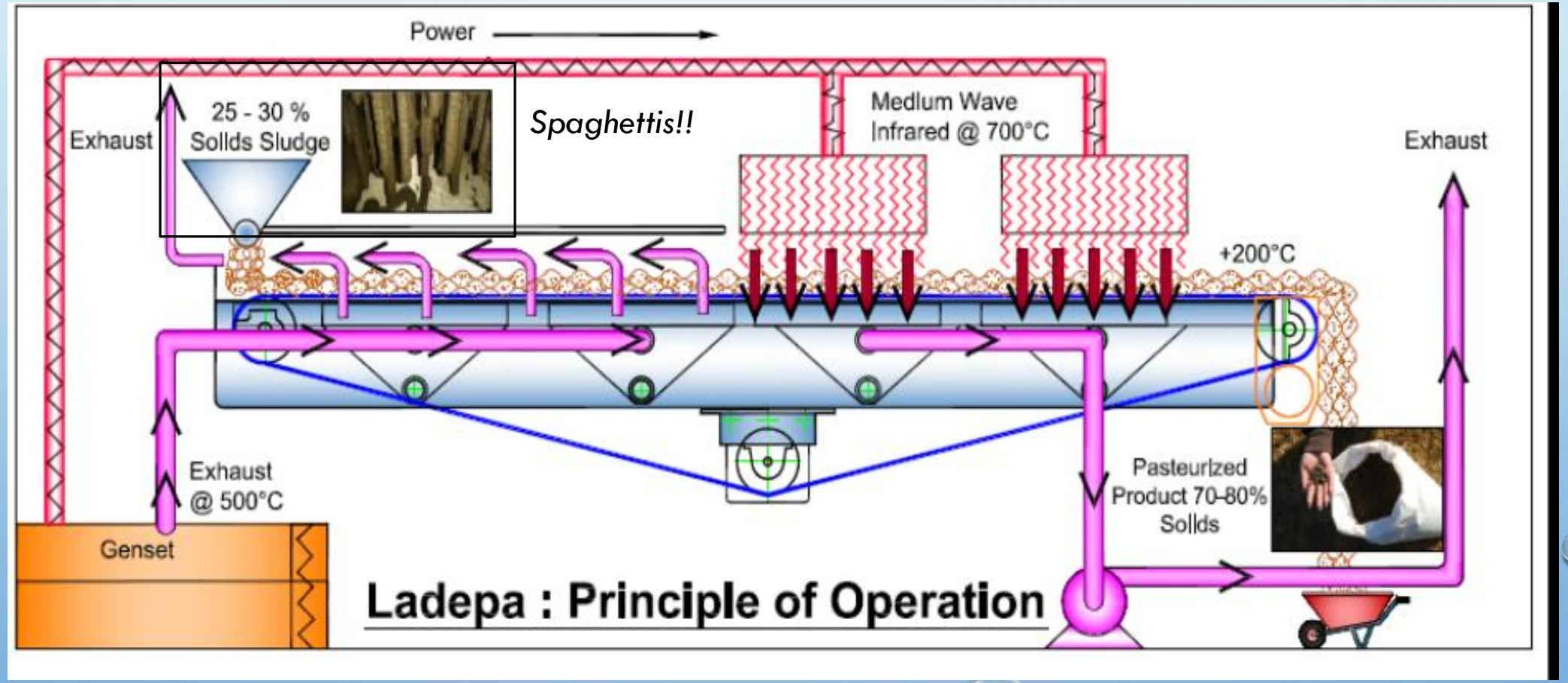
~ consumption 8 litres per hour

FEEDING



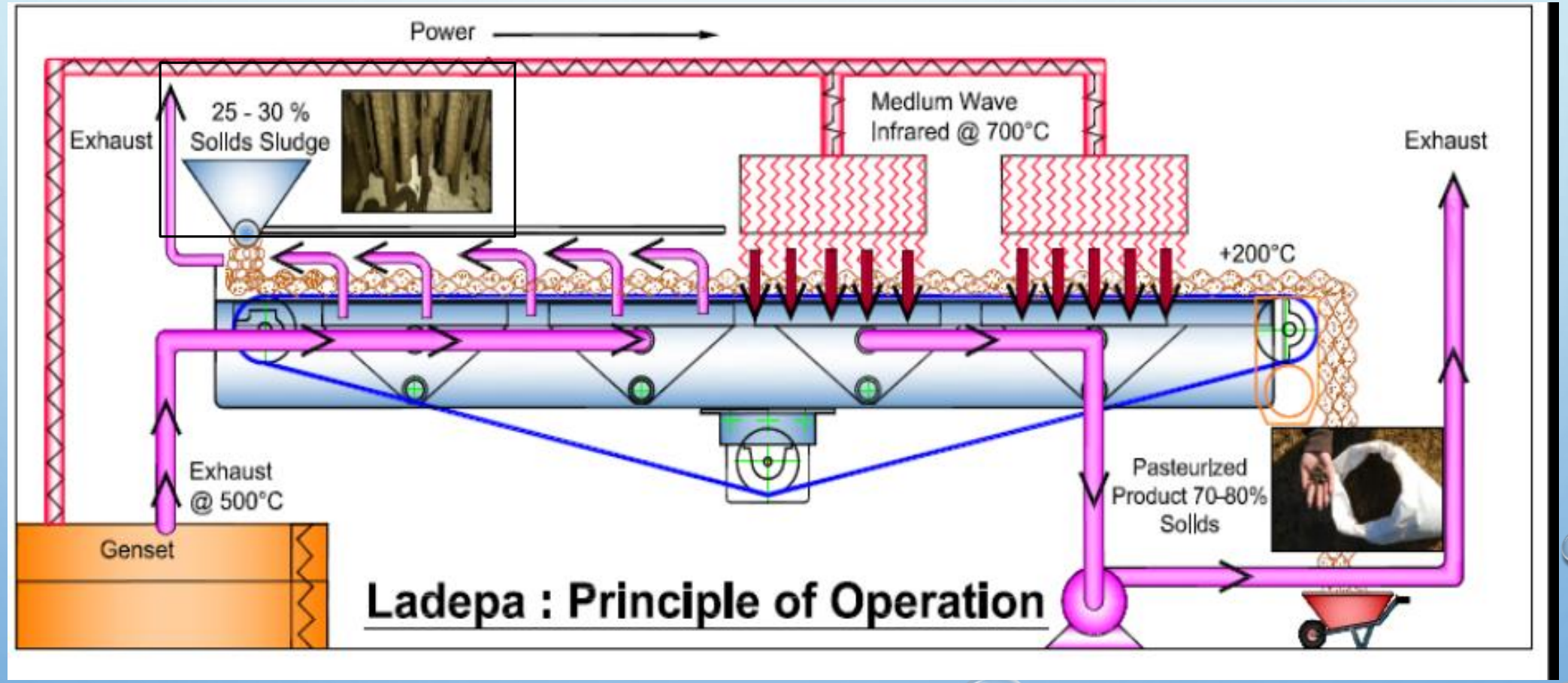
1 tonne of faecal sludge per hour

EXTRUSION



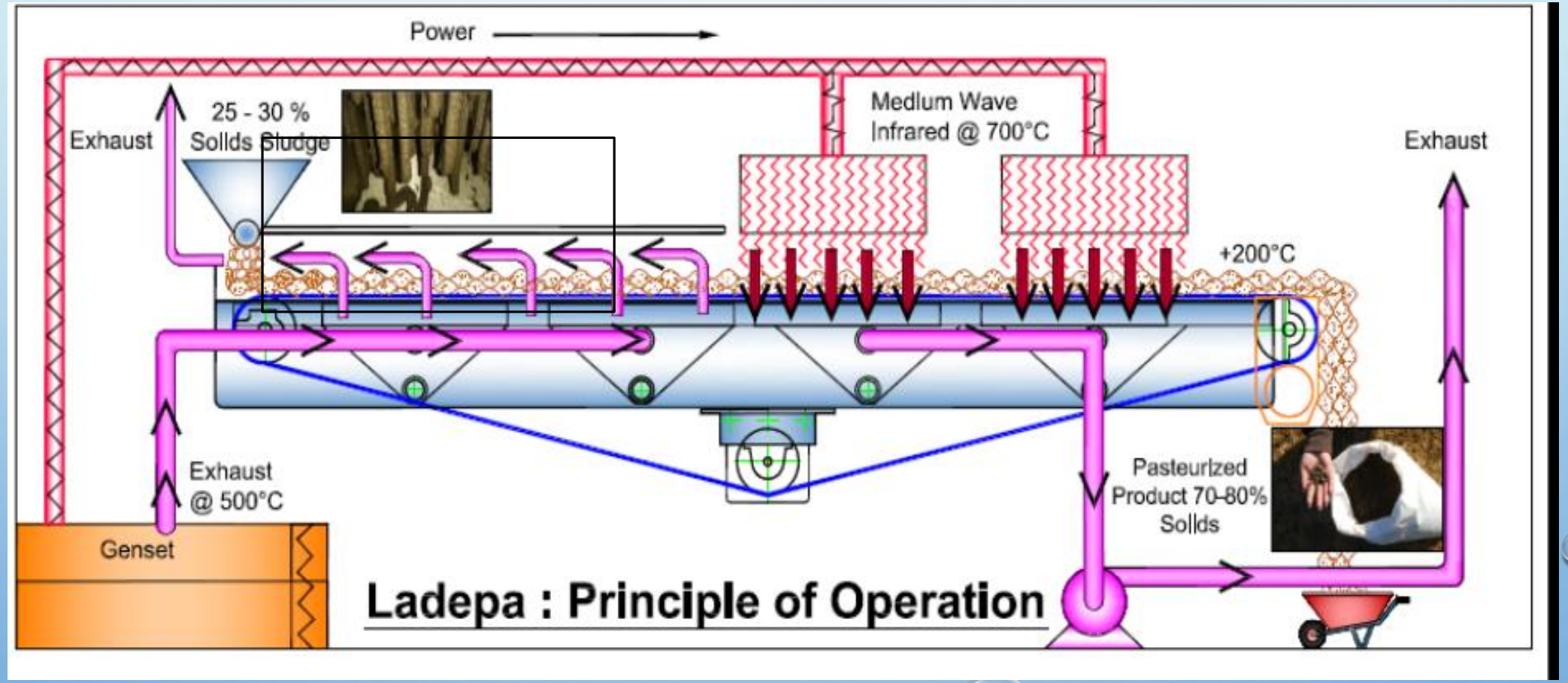
0.9 tonne of faecal sludge extruded per hour + 0.1 tonne of detritus separated

PRE-HEATING



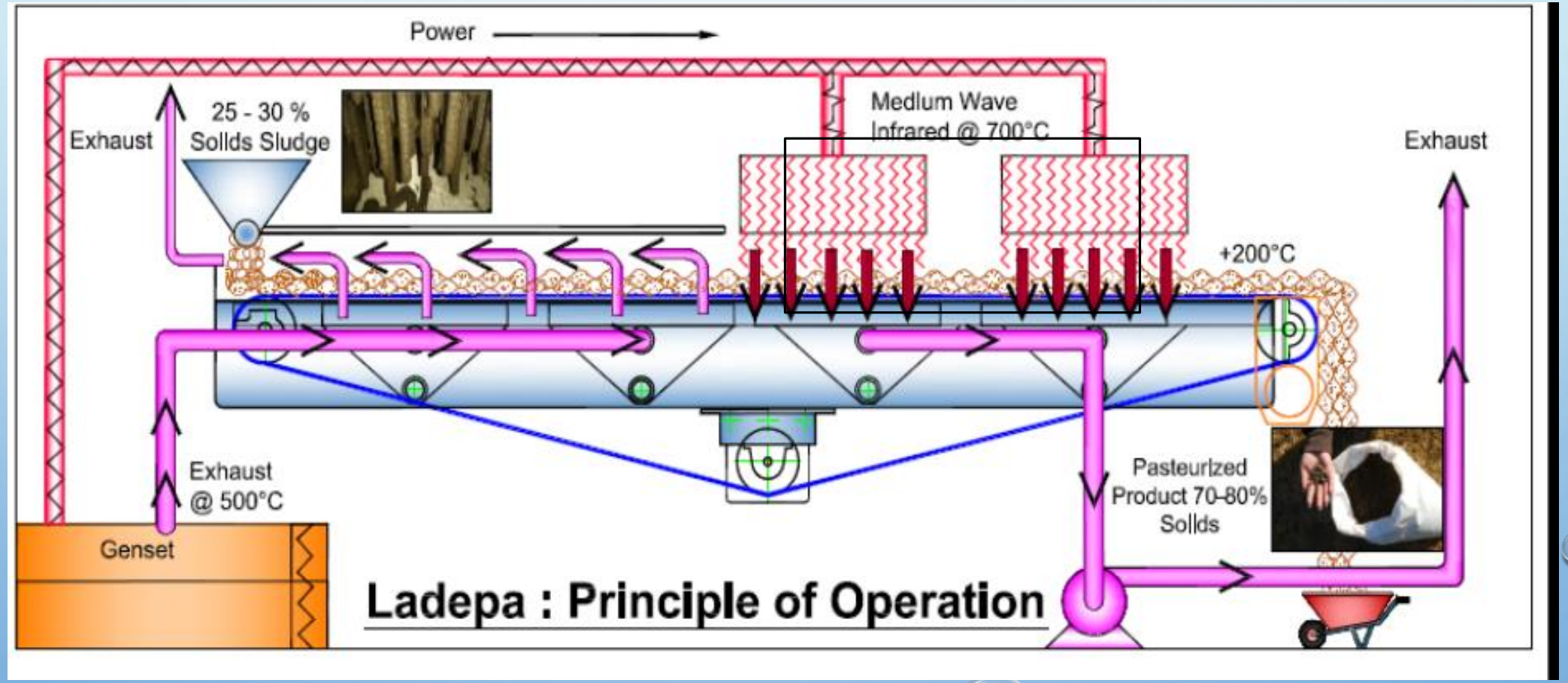
With the hot exhaust gas from the diesel generator

INFRARED HEATING



Infrared heating similar principle than that from a toaster machine!

END-PRODUCT



0.3 tonnes of dried and pasteurized product contained in bags


SLUDGE TREATMENT JOINT VENTURE:
PATENT REGISTRATION NUMBER: 2010/12000
ETHEKWINI MUNICIPALITY
CAE
CAPE ADVANCED ENGINEERING


Bobcat
753

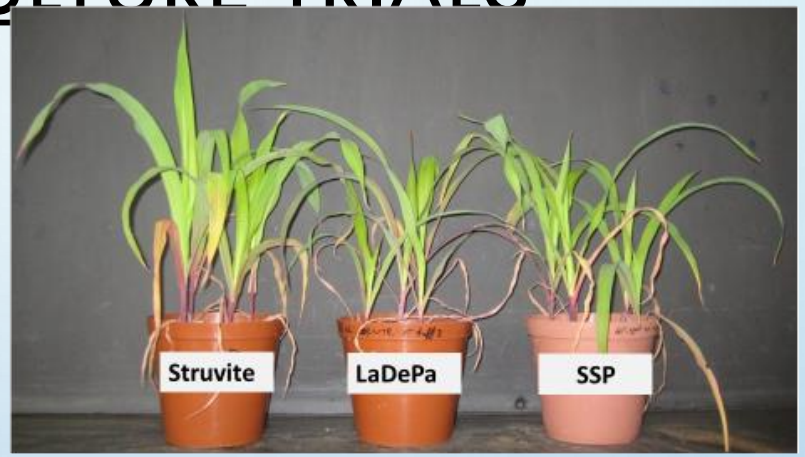
LAB SCALE LADEPA PROTOTYPE

LABORATORY ANALYSIS OF PELLETS

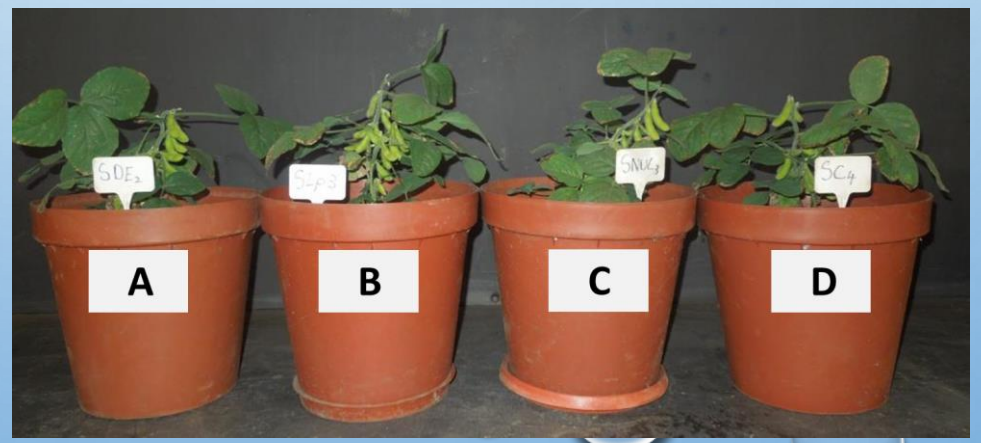
- Moisture content analysis
- Parasite analysis (Ascaris)
- Nutrient content analysis
- Thermal properties

AGRICULTURE TRIALS

LaDePa applied at 3 different rates half (H), recommended (R), double recommended (D) and control (C) on maize plants growing on a sandy soil (Cartref) for 6 weeks.



Maize at 6 WAP after application of Struvite, LaDePa pellets and single super phosphate (SSP)at half the recommended rate on a sandy soil



RESEARCH OUTCOMES

- 80% moisture removal in 8 minutes at favourable conditions
- High deactivation of Ascaris eggs in 4 minutes
- Nutrient content close to that from organic fertilizers, as manure and home compost (slightly higher for some compounds)
- Good growth of plants with LaDePa pellets
- Fuel characteristics similar than that from wood and some coal rank

THANK YOU!

Velkushanova@ukzn.ac.za

WATER AND SANITATION LEGISLATION

- **1994 NEW SOUTH AFRICA**
- **1994** WHITE PAPER ON WATER SUPPLY AND SANITATION POLICY
- **1996 CONSTITUTION OF THE REPUBLIC OF SOUTH AFRICA**
  - ***"EVERYONE HAS A RIGHT TO AN ENVIRONMENT THAT IS NOT HARMFUL TO THEIR HEALTH OR WELL-BEING"***
  - ***"EVERYONE HAS THE RIGHT TO HAVE ACCESS TO (…) SUFFICIENT FOOD AND WATER".***
- **1997 WATER SERVICES ACT 108**
  - PROVIDING FOR THE RIGHT OF ACCESS TO BASIC WATER SUPPLY AND SANITATION NECESSARY TO SECURE SUFFICIENT WATER AND AN ENVIRONMENT NOT HARMFUL TO HUMAN HEALTH AND WELL-BEING
  - ***"RIGHT TO BASIC SANITATION."***
- **1998 NATIONAL WATER ACT 36**
- **2000 FREE BASIC SERVICES (FBS) POLICY**
  - ***FREE BASIC SERVICES FOR THE POOR INCLUDING WATER SUPPLY, SANITATION, REFUSE REMOVAL AND ELECTRICITY***
- **2002** SANITATION TECHNOLOGY OPTIONS
- **2003 STRATEGIC FRAMEWORK FOR WATER SERVICES**
  - ***WATER IS LIFE SANITATION IS DIGNITY***
- **2004 NATIONAL WATER RESOURCE STRATEGY**
- **2005 NATIONAL SANITATION STRATEGY**
- **2009 FREE BASIC SANITATION (FBSAN) IMPLEMENTATION STRATEGY**
  - ***"PROVIDING ALL CITIZENS WITH FREE BASIC SANITATION BY 2014"***
- **2013 NATIONAL WATER RESOURCE STRATEGY (UPDATE FROM 2004)**