MS4SSA
2017
Worcester MA, USA

An initiative to improve mathematics and science for Sub-Saharan Africa

MATHEMATICS AND SCIENCE FOR SCHOOLS IN SUB-SAHARAN AFRICA

TRAINING PROGRAM (MAY 17 – MAY 26, 2017)

CLAY MODULES FOR PROJECT-BASED LEARNING

THE PROCESSING AND TESTING OF CERAMIC WATER FILTERS

John OBAYEMI, Pierre-Marie NIGAY and Wole SOBOYEJO

MAY 24th 2017

WORCESTER POLYTECHNIC INSTITUTE

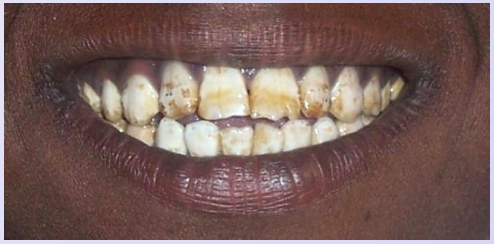
WATER TREATMENT
CONTEXT

Contaminated water

- Biggest cause of the decline in life expectancy in Africa
- Bigger impact on life expectancy than that of HIV
- Example of Nigeria: 5000 lives lost per day

Different types of contamination

- Bacterium (E. Coli…) that may cause infectious diarrhea
- Chemicals (Fluoride…) that may cause skeletal deformities
- Viruses (Hepatitis…) that may cause liver infection



WATER TREATMENT
BACKGROUND

BACTERIUM	CHEMICALS	VIRUSES
Trapping in the pores of porous materials (such as fired clay ceramics)	Recombination with reactive materials (such as hydroxylapatite)	Adhesion on the surface of sorbent materials (such as alumina)

Objectives

1. Development of porous clay ceramics with hydroxylapatite and alumina to remove both bacterium, chemicals and viruses from contaminated water
2. Measurement of potable water filtered by ceramic water filter
3. Suggesting alternative designs for multi-ceramics filtration systems

WATER FILTERS

PROCESSING

Clay | Sawdust | Apatite | Alumina | Water

Mixing

Casting

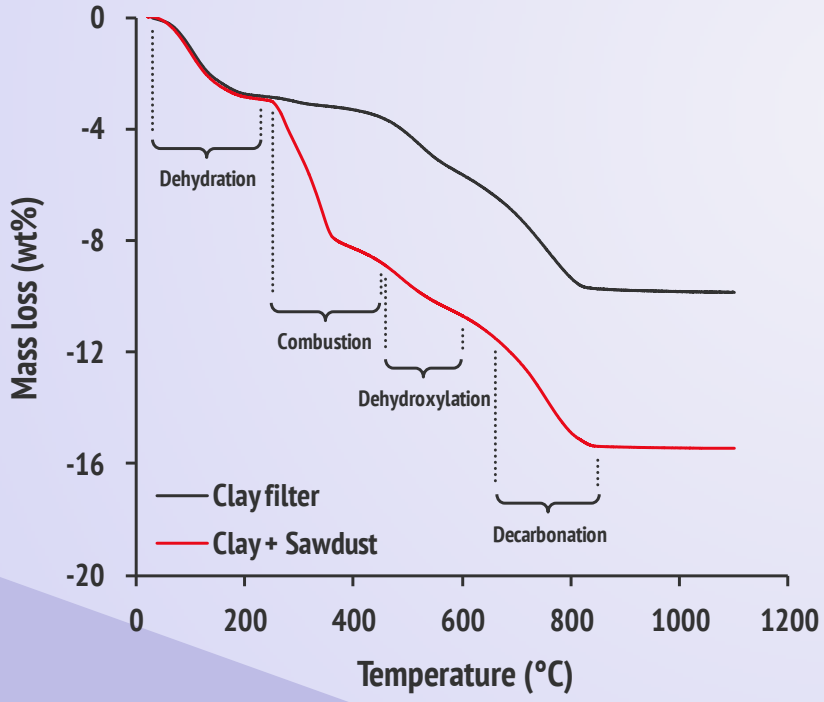
Firing

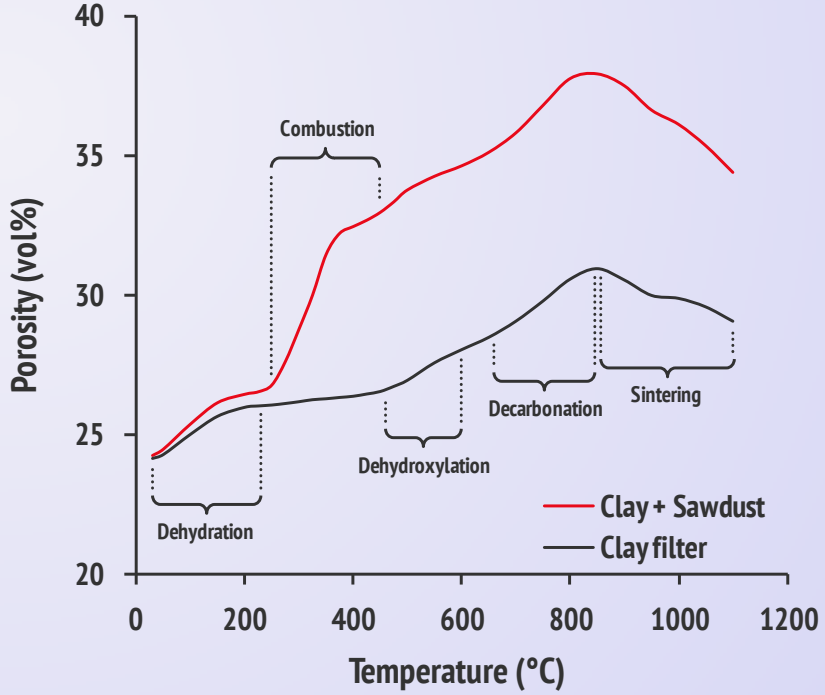
Ceramic water filter

WATER FILTERS
PROCESSING

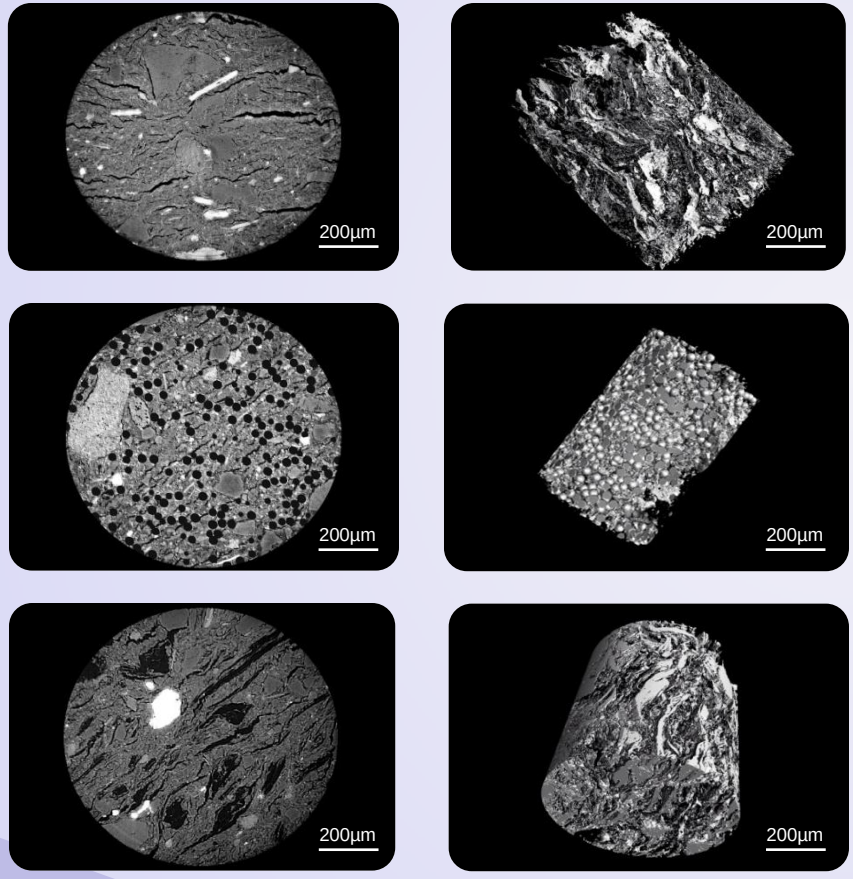
Firing of the materials at temperatures up to 800°C

- Combustion of the sawdust that results in a porosity formation
- Sintering of the clay particles that provides a mechanical strength





WATER FILTERS
STRUCTURE



Control of the ceramic water filters structure

Combustion of the sawdust during the firing process (Air)

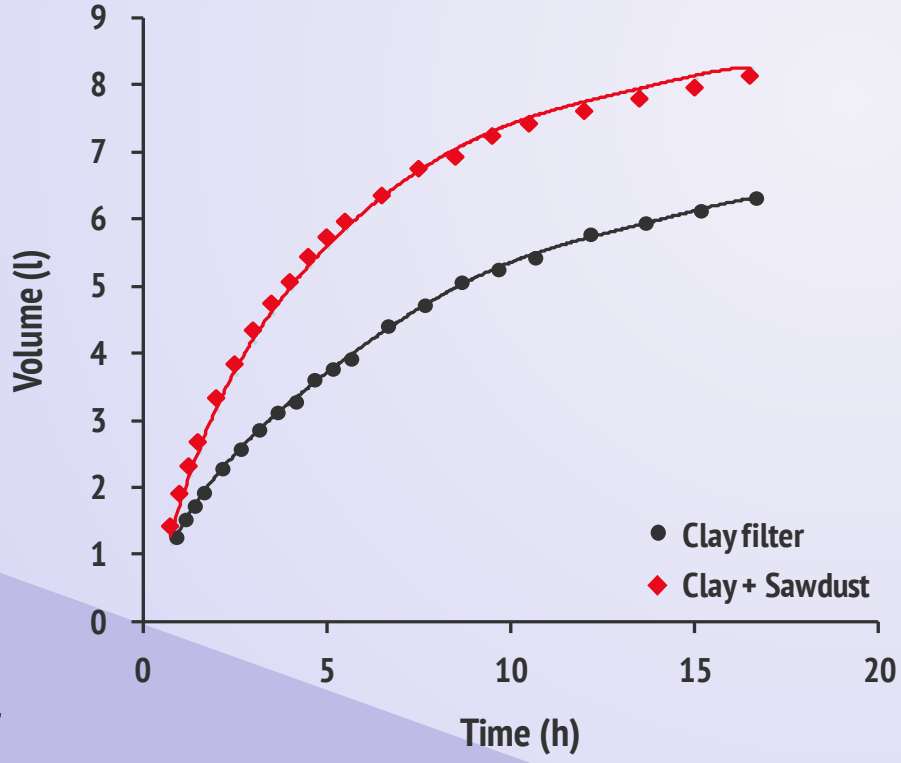
Formation of pores equivalent to the morphology of the particles

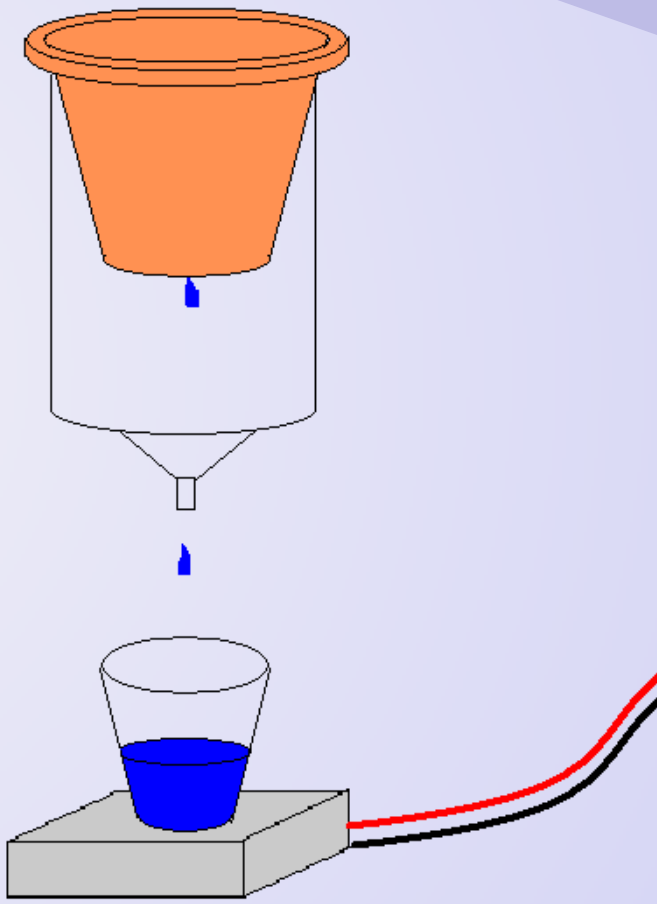
Inter-connected pores with a path for water using large particles of sawdust in the form of fibers

WATER FILTERS
STRUCTURE

Development of permeable materials

- Permeability due to the interconnection of pores
- Increase of the permeability with the porosity





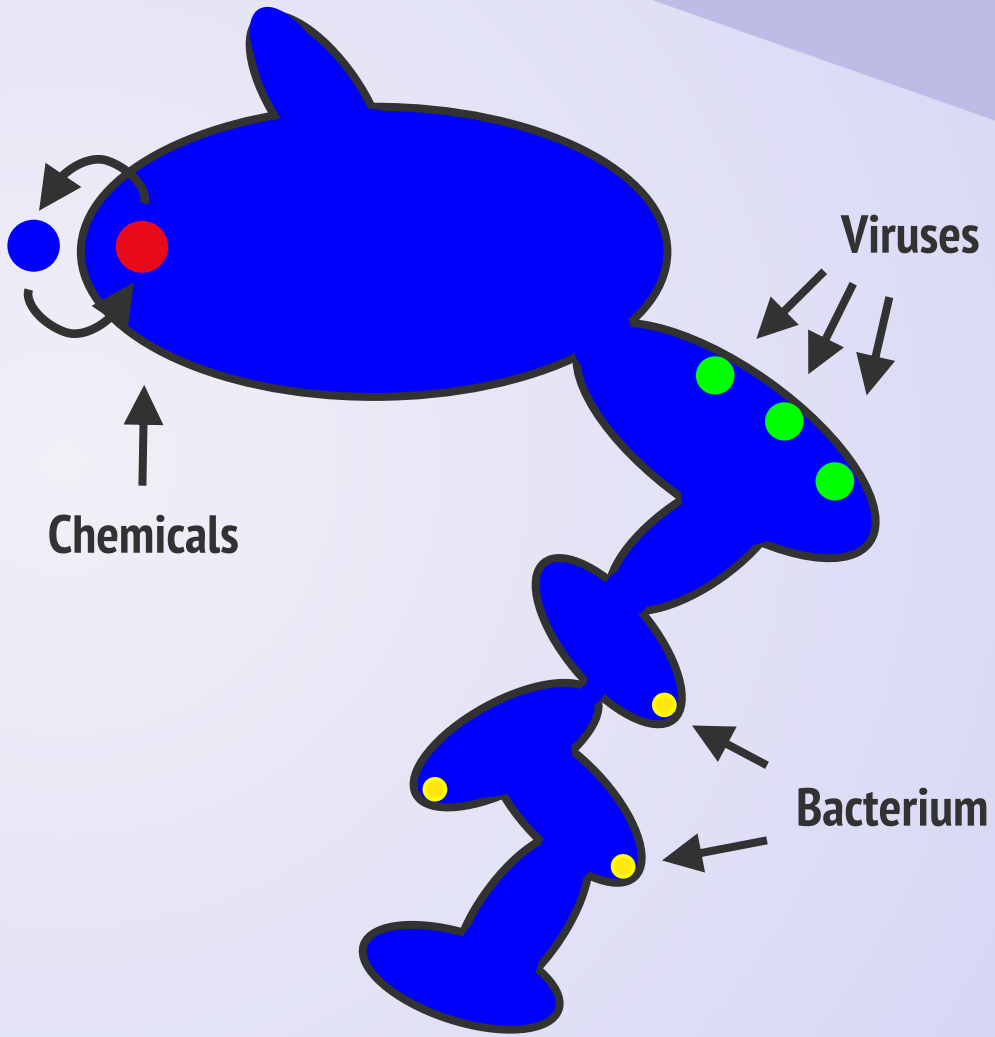
WATER FILTERS
PROPERTIES

Capture of pathogens

- Deposition of bacterium in traps of the porous network
- Transformation of chemicals at the interface with hydroxylapatite
- Adhesion of viruses onto alumina

Relation with the structure

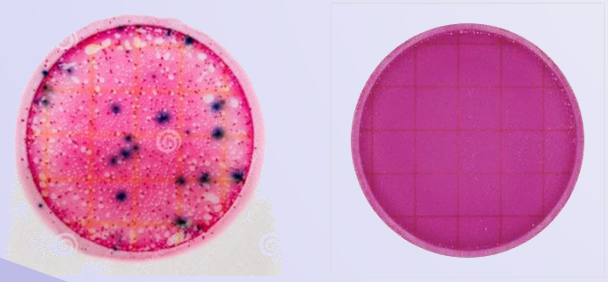
- Increase in the capture efficiency of pathogens with the water flow
- Increase in the water flow with the permeability



WATER FILTERS
PROPERTIES

E. Coli filtration

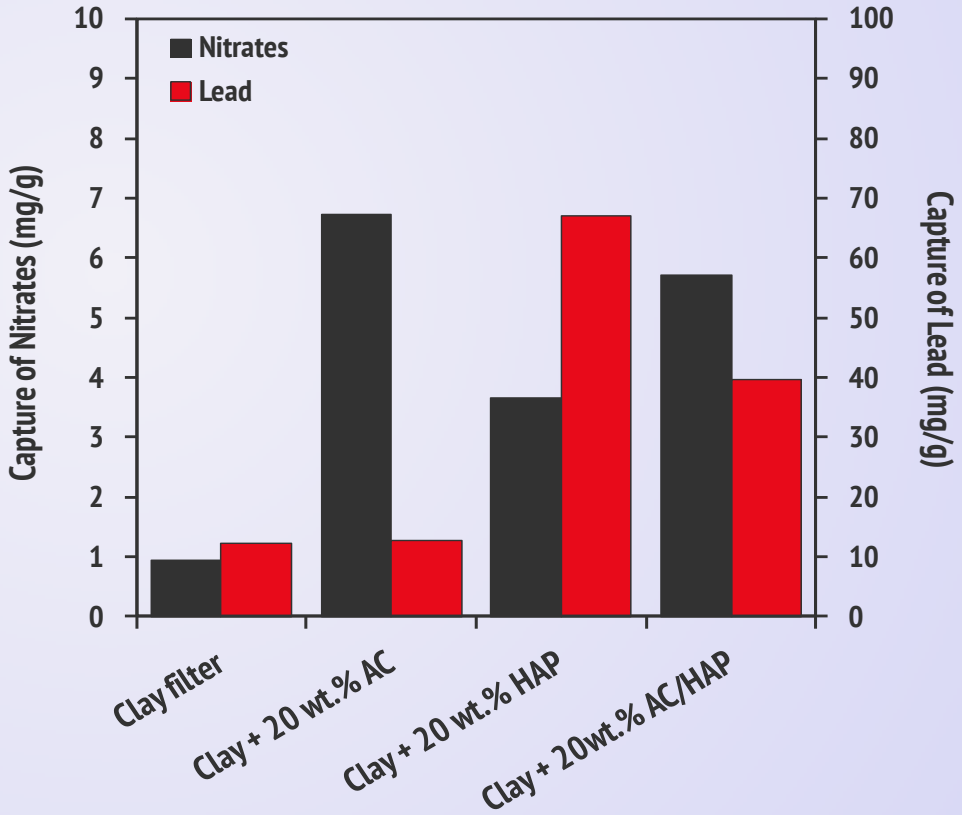
Clay:Sawdust	Removal (%)
45:55	99.91
50:50	99.96
55:45	99.68
65:35	99.99



Before

After

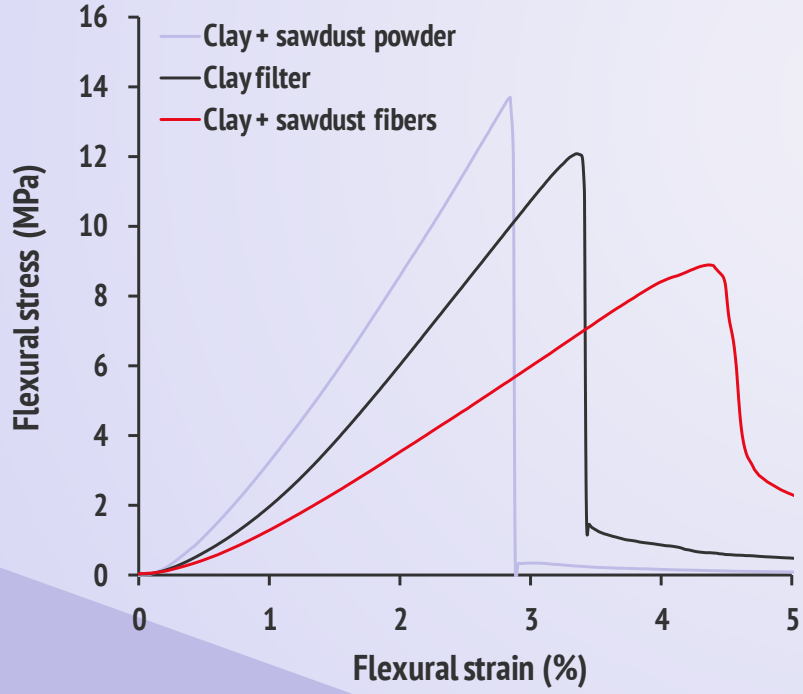
Chemicals filtration

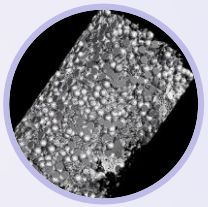


WATER FILTERS
PROPERTIES

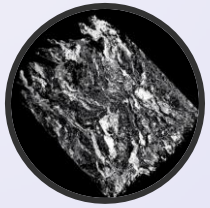
Control of the mechanical properties from the structure

- Increase of the strength and Young's modulus with small pores (sawdust powder)
- Increase of the strain and toughness in the case of anisotropic pores (sawdust fibers)

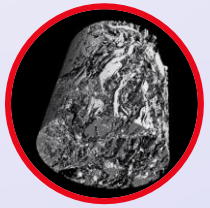




Clay + sawdust powder



Clay ceramic



Clay + sawdust fibers

WATER FILTERS
PROPERTIES

Group Discussion

1. Do you observe any trend in the flow rate values? Yes or No? Explain the factors that might have affected flow rate data obtained.

WATER FILTERS
PROPERTIES

Group Discussion

1. Do you observe any trend in the flow rate values? Yes or No? Explain the factors that might have affected flow rate data obtained.

2. Based on the knowledge gained from this session, suggest/sketch (with rationale) a new design for the ceramic water filter.

WATER FILTERS
PROPERTIES

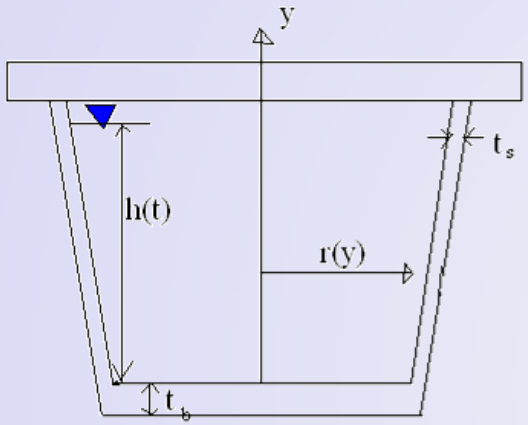
Group Discussion

1. Do you observe any trend in the flow rate values? Yes or No? Explain the factors that might have affected flow rate data obtained.

2. Based on the knowledge gained from this session, suggest/sketch (with rationale) a new design for the ceramic water filter.

3. From your experimental results, provide a schematic diagram of a multi-ceramic water filtration system, which has the potential of providing safe drinking water for a community of 300-500 people. You may use data from your experiment for explanation.

WATER FILTERS
PROPERTIES



Darcy's law:

$$Q = \frac{\kappa A}{L}\frac{\Delta p}{\mu}$$

CONCLUSIONS
PROSPECTS

Conclusions

- Removal of bacterium, chemicals and viruses from contaminated water
- Potable water for 6 persons a day using one ceramic water filter
- Establishment of companies for the dissemination of the technology

Prospects

- Education to avoid misconceptions associated with filter use
- Scale up with larger filters number

MS4SSA
2017
Worcester MA, USA

An initiative to improve mathematics and science for Sub-Saharan Africa

MATHEMATICS AND SCIENCE FOR SCHOOLS IN SUB-SAHARAN AFRICA

TRAINING PROGRAM (MAY 17 – MAY 26, 2017)

THANK YOU FOR YOUR ATTENTION