REMOVAL OF HEAVY METALS FROM SMALL SCALE GOLD MINING WASTEWATER USING ON-SITE COCOPEAT FILTER BED SYSTEM

Maria Antonia N. Tanchuling
University of the Philippines

2nd International Workshop of the 3E Nexus Initiative for Sustainable Development in Asian Countries
Bali, Indonesia
26 - 27 February 2015

PHIL. GOLD PRODUCTION

January – June 2011

Producer	Quantity (kg)	Value (PhP)
Primary Producers excluding SSM	4,995	10,113,688,449
SSM	**14,907**	**28,958,174,923**
Secondary Producers	2,903	5,445,771,389
TOTAL	**22,804**	**44,517,634,761**

SOURCE: http://www.mgb.gov.ph/Files/Statistics/MetallicProduction.pdf

ACCORDING TO MINES AND GEOSCIENCES BUREAU OF DENR

70-80% of Gold Sellers come from the small-scale mining industry (with about 1-2 M direct dependents)

SOURCE: http://www.tribune.net.ph/index.php/business/item/6846-tax-sends-bsp-gold-purchase-down-to-75

Small-Scale Mining (SSM)

DESCRIPTION

- Crude processing up to recovery of metals (40-60% recovery only)
- **LIMITED capability for addressing environmental concerns**

NEEDS:

- technical assistance to be able to optimize recovering process
- technical assistance to address environmental concerns
- locally viable and affordable technologies for downstream processing

Mineral Extraction with Responsibility for Sustainability (MinERS)

Clean Gold Extraction Technologies

Clean wastewater treatment technologies

Socially, environmentally and economically acceptable practices

A

Non-Hazardous Methods of Gold Extraction for Philippines Small-Scale Mining Applications

DR. HERMAN D. MENDOZA, DR. ENG.

C

Optimizing the Effectivity of Coco-Peat Filter Bed in Field Applications

DR. MARIA ANTONIA N. TANCHULING, PH.D.

E

Nanofiber Membrane Adsorption as Third Level Waste Water Treatment Method for Small-Scale Mining Operations

DR. LESLIE JOY L. DIAZ, DR. ENG.

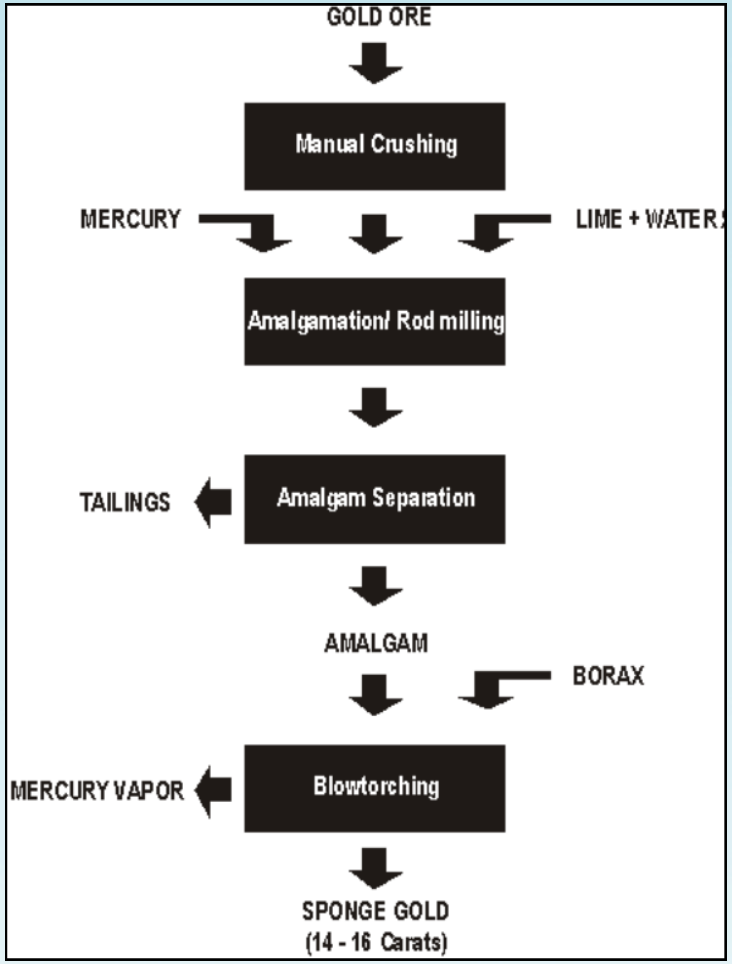
G

The Gold and Copper Chase: Life Cycle Analysis of Sustainable Small-Scale Production System

DR. VIRGINIA J. SORIANO, PH.D.

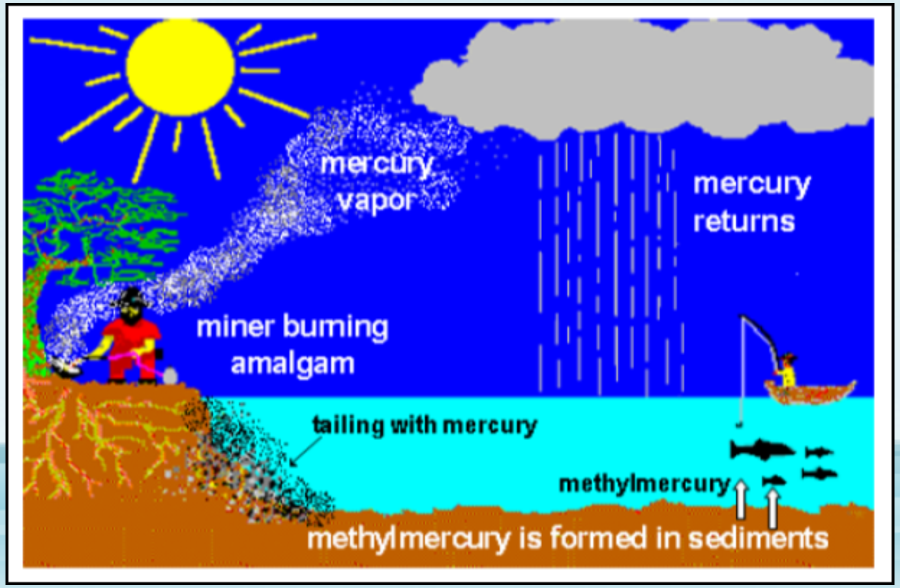
Introduction

- Small-scale gold mining (SSGM) in the Philippines contributes significantly to gold production and rural employment
- Amalgamation process is used to separate gold from mined ores
- Wastewater from ball mill facilities released to the water bodies untreated



Small scale gold mine tailings and wastewater

- Turbid and high suspended solids
- Contains elevated amount of mercury and other heavy metals
- Do not meet government disposal limit
- Wastewater treatment is needed



Heavy metal removal techniques

Conventional and advanced methods

- Reverse osmosis, electrodialysis, ultrafiltration, ion-exchange, chemical precipitation

Disadvantages

- Not cost-effective due to incomplete metal removal
- High reagent and energy requirements
- Generation of toxic sludge and other waste sludge that requires careful disposal

Biosorption using Coco peat

- Adsorption as an alternative technique for heavy metal removal
- Advantages :
  a) low cost
  b) high efficiency
  c) minimization of chemical and/ or biological sludge
  d) possibility of metal recovery
  e) Low energy requirements
- Utilize non-living materials and agricultural wastes as sorbents

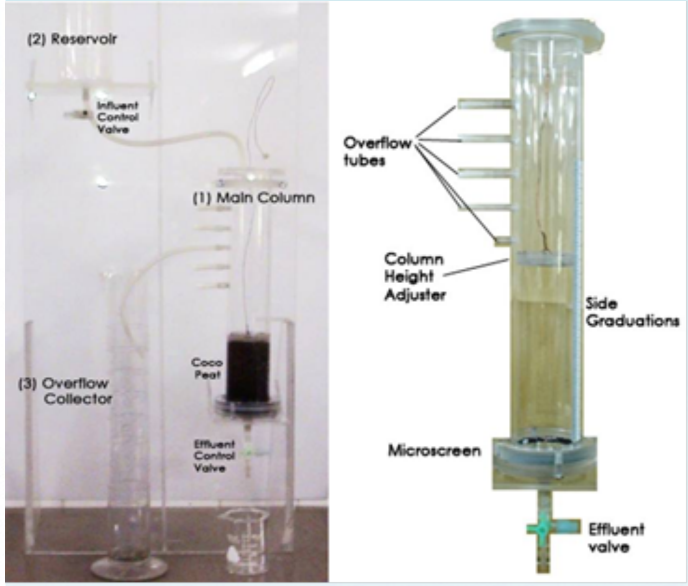
COCO PEAT

- Promising biosorbent rom coconut husks
- Consist mainly of lignin, cellulose, hemicellulose, and some pectin and extractives
- Proven effective sorbent of heavy metals from aqueous solutions.
- Can be used as media in a filtration bed

Previous studies using coco peat

Column and batch experiments

- high efficiencies in the removal of heavy metals (Pb, Cu, Cd, Ba, Cr) from the aqueous solutions



Laboratory-scale vertical flow filter bed system

Objectives

- To study the removal efficiency of an on-site filter bed using cocopeat as adsorbent to remove As, Hg and Pb from actual SSGM wastewater.
- To determine the effect of suspended solids of the wastewater in the flow of water in the filter bed system.

Materials and Methods

- **Wastewater Characterization**

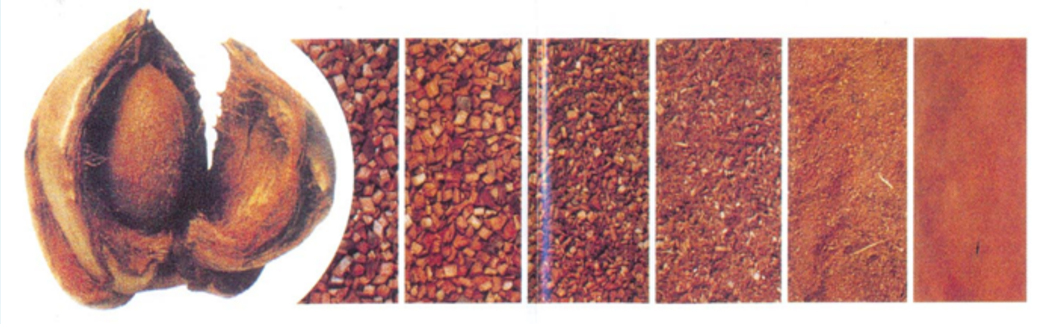
  Horiba Multi Water Quality Checker for pH, ORP, EC, Turbidity, DO, TDS

  Gravimetric method for TSS

  AAS for heavy metals (As, Hg, Pb)

Parameter	Values
pH	5.77
Oxidation Reduction Potential (ORP)	292.56 mV
Electrical Conductivity (EC)	0.29 µS/cm
Turbidity	184.56 NTU
Dissolved Oxygen (DO)	3.89 mg/L
Total Dissolved Solids (TDS)	0.19 g/L
Total Suspended Solids (TSS)	0.123 g/L

Coco peat as Adsorbent



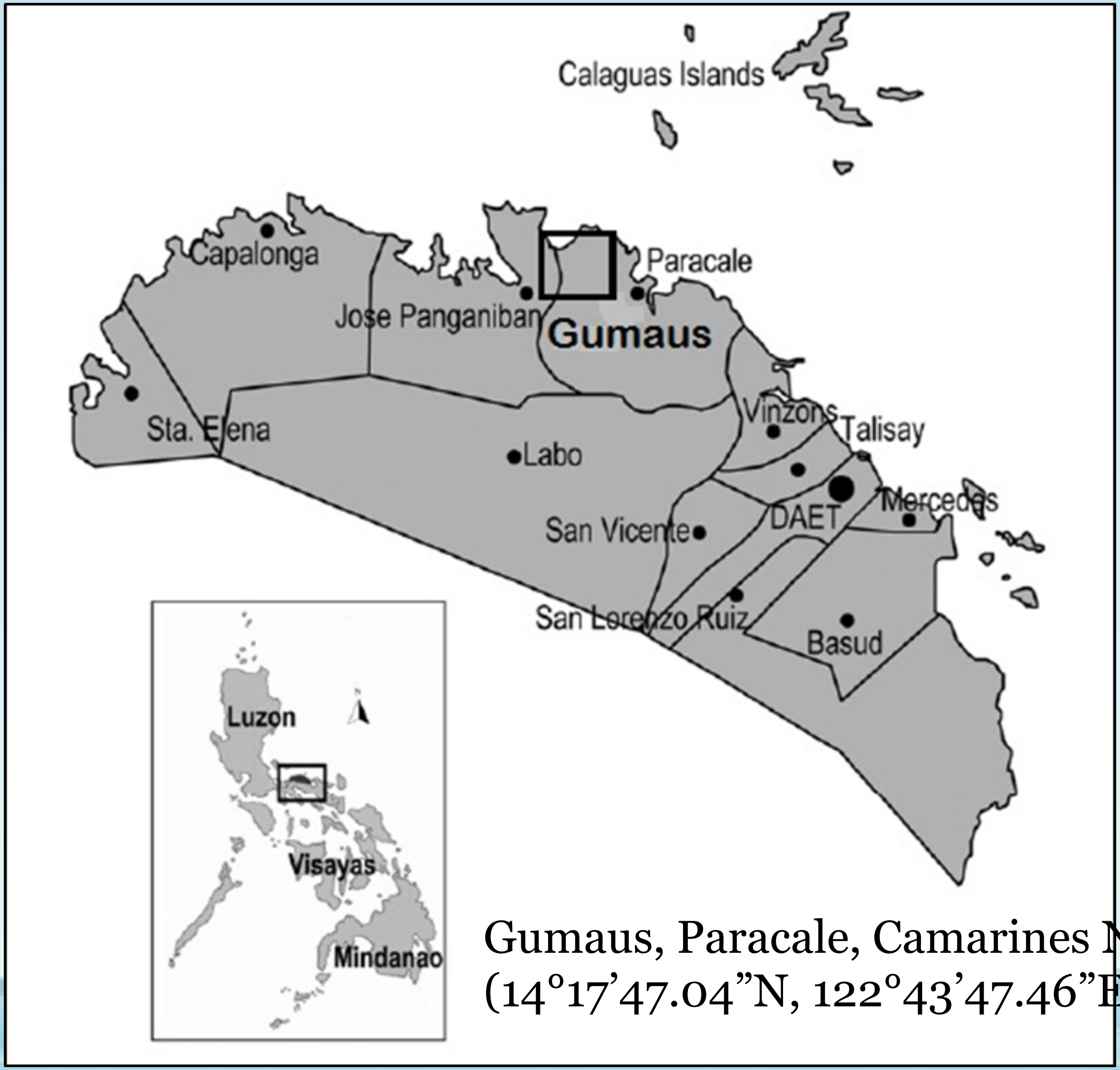
Present Study

Heavy Metals	Value
As, mg/kg	<0.01
Pb, mg/kg	<0.10

Previous Study

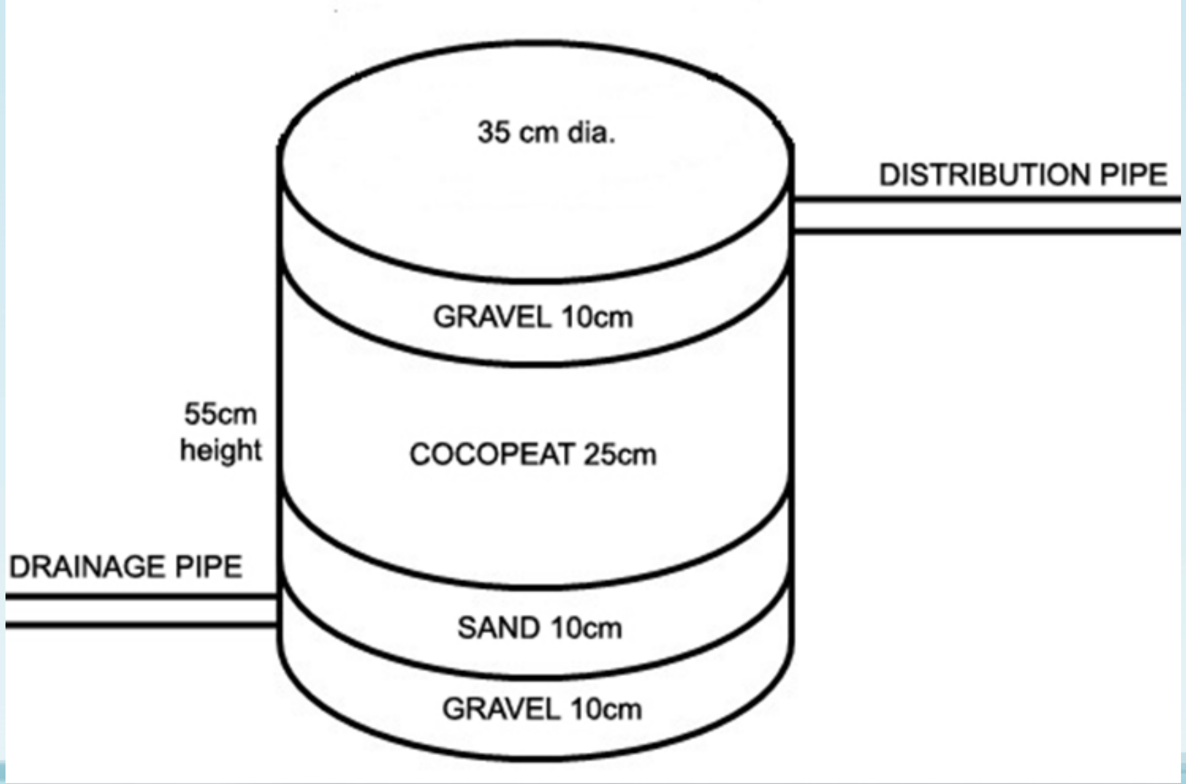
Parameter	Unit	Value
Moisture Content	%	17.47
Ash Content	%	7.45
pH	pH	5.70
Bulk Density	g/cm^3	0.075
Particle Size Distribution	mm	2.00 to <0.075
Coefficient of Uniformity		3.00
Coefficient of Graduation		0.96
Effective Particle Size	mm	0.23
Total Organic Matter	% w/w dry basis	96.93
Lignin	% w/w dry basis	59.02
Cellulose	% w/w dry basis	28.30
Hemicellulose	% w/w dry basis	8.72
Extractives (Alcohol-Benzene)	% w/w dry basis	2.24
Cation Exchange Capacity	meq/100 g	151
Anion Exchange Capacity	meq/100 g	0.068
Specific Surface Area	m^2/g	0.1159
Trace Heavy Metal		
Concentrations	mg/kg	3.9
Cu	mg/kg	441
Fe	mg/kg	N.D.
Pb		

Project Site



Gumaus, Paracale, Camarines Norte
(14°17’47.04”N, 122°43’47.46”E)

Reactor Set Up



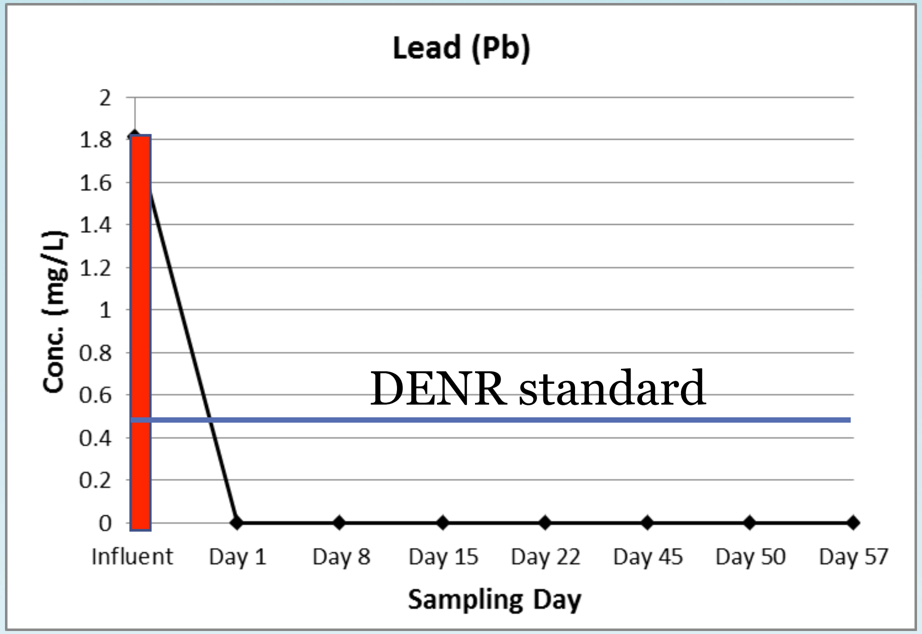
Wastewater Sampling

- Weekly sampling from the site
- Heavy metal analyses done in the laboratory

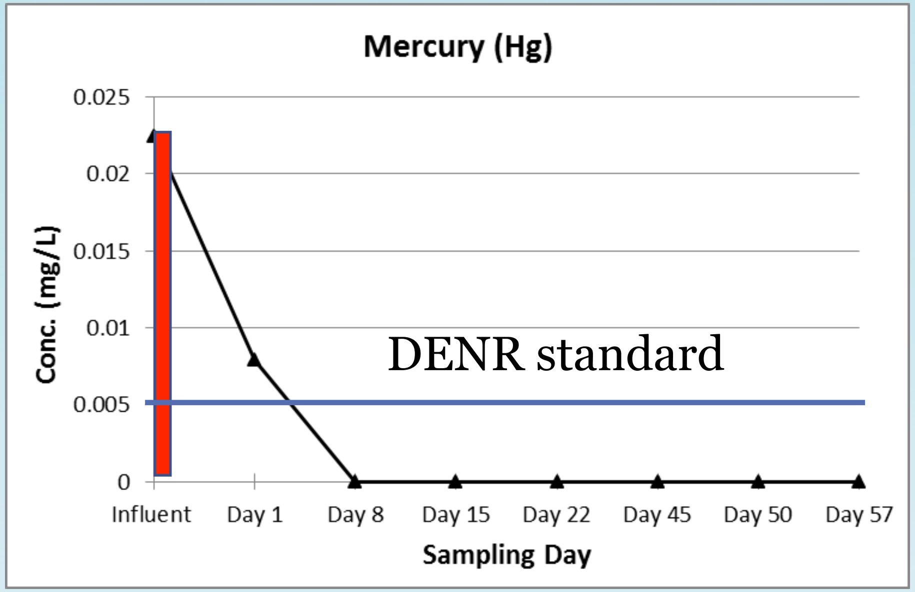
Total metal concentrations were tested using:

- Hydride Generation AAS for As
- Flame AAS for Pb
- Cold Vapor AAS for Hg

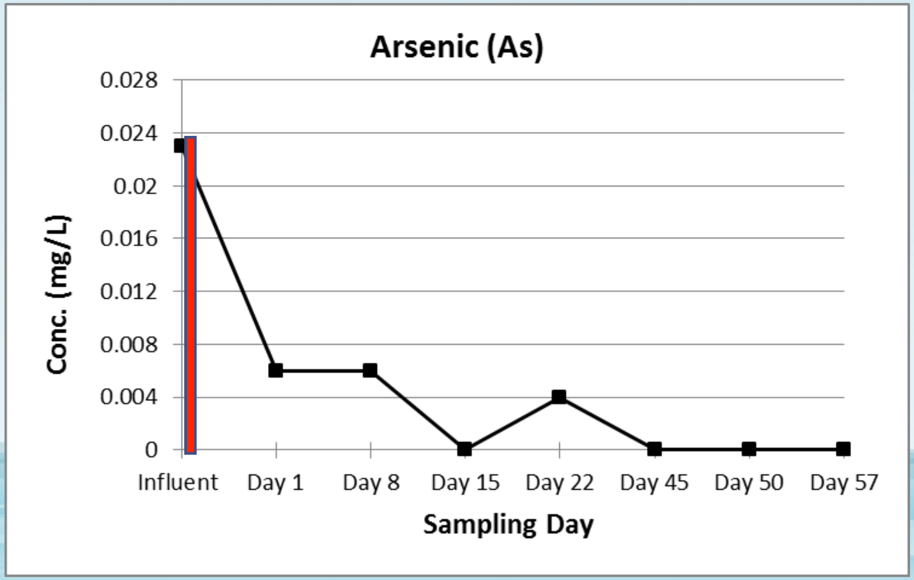
Results



Lead (Pb)
Conc. (mg/L)
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
DENR standard
Influent
Day 1
Day 8
Day 15
Day 22
Day 45
Day 50
Day 57
Sampling Day

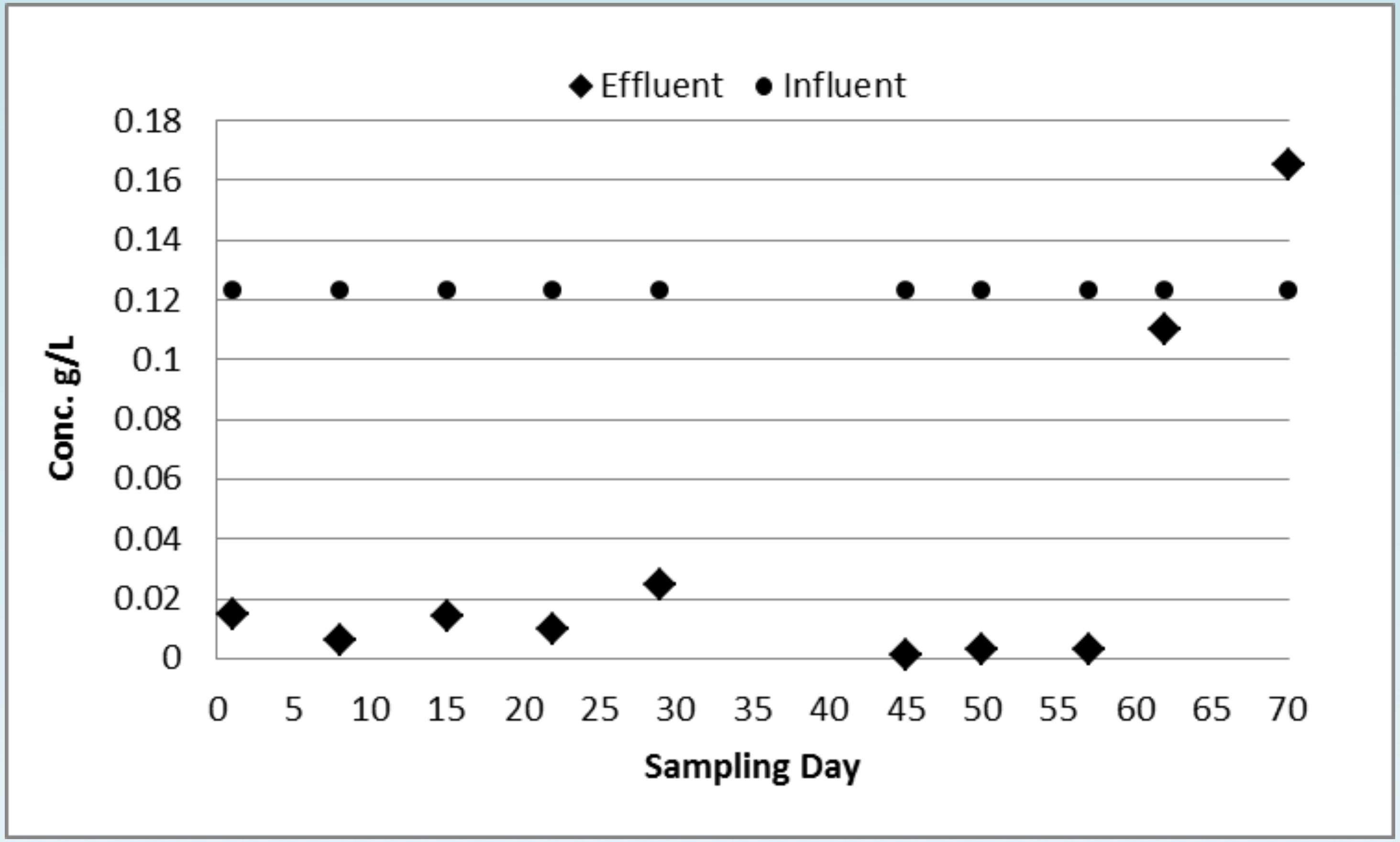


Mercury (Hg)
Conc. (mg/L)
0.025
0.02
0.015
0.01
0.005
0
DENR standard
Influent
Day 1
Day 8
Day 15
Day 22
Day 45
Day 50
Day 57
Sampling Day



Arsenic (As)
Conc. (mg/L)
0.028
0.024
0.02
0.016
0.012
0.008
0.004
0
Influent
Day 1
Day 8
Day 15
Day 22
Day 45
Day 50
Day 57
Sampling Day

Total Suspended Solids

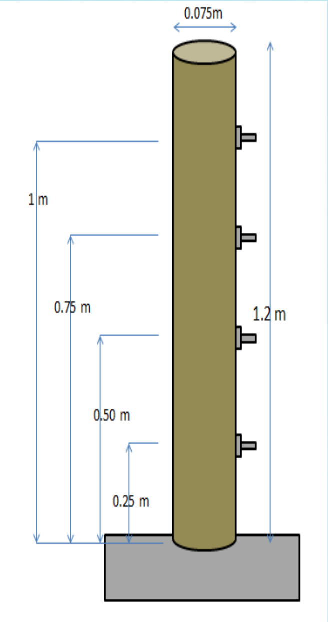


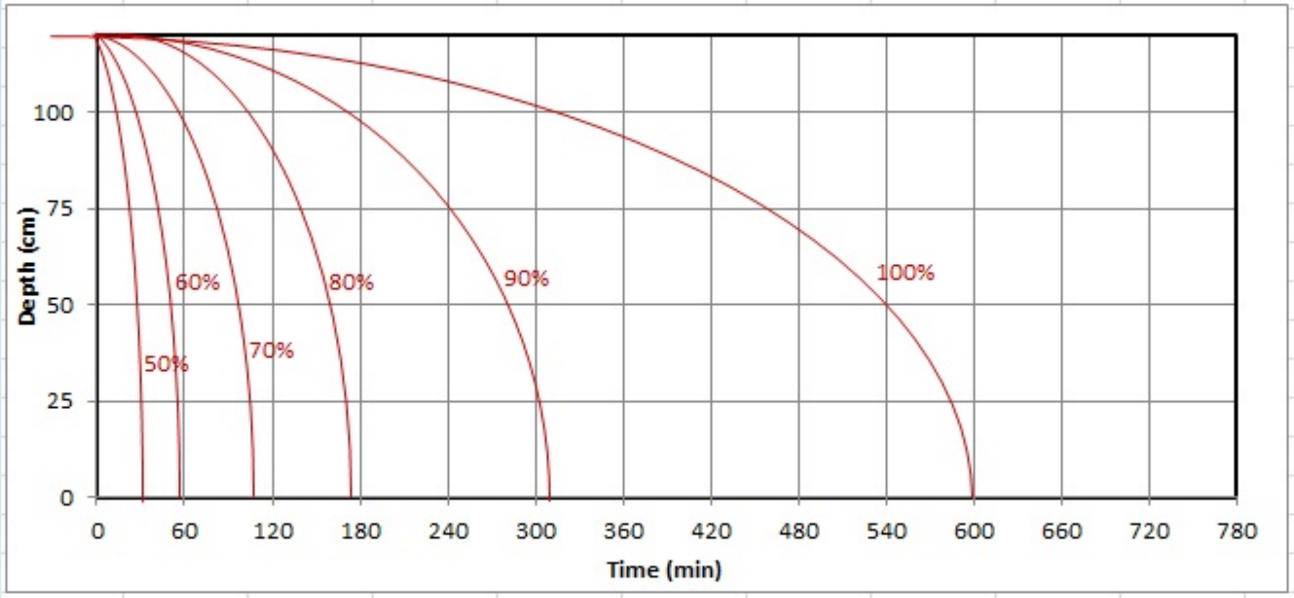
Conclusions

1. The onsite filter bed system using cocopeat as adsorbent was shown to be efficient in reducing the concentration of heavy metals (As, Hg, Pb) from the actual SSGM wastewater.
2. After 2 – 2.5 months of continuous operation, the effluent heavy metal concentrations are within the concentration limits prior to disposal set by DENR for Class C waters.
3. Due to high total suspended solids in the SSGM wastewater, the reactor clogged after 2.5 months and thus cannot be used for further use.

Sedimentation experiments

Sedimentation Analysis

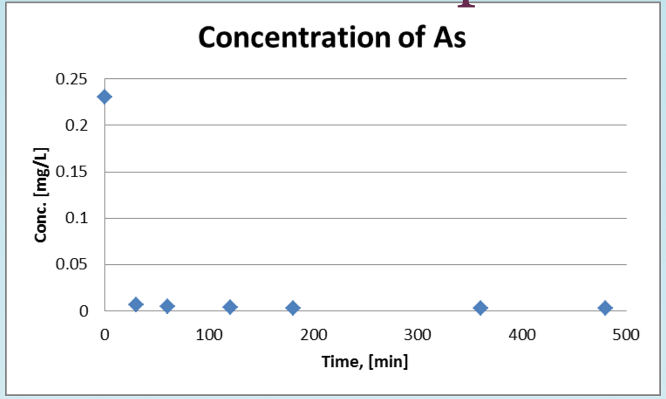


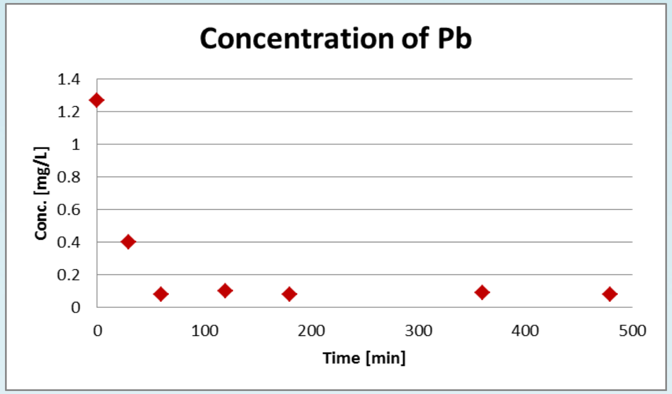


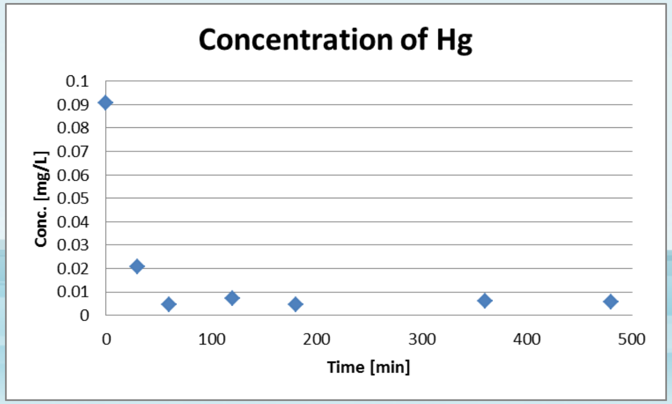
Settling column experiment results show that:

- After 480min at depths 75cm and 100cm, suspended solids were removed.
- After 600min, all particles were settled at the bottom of the column.

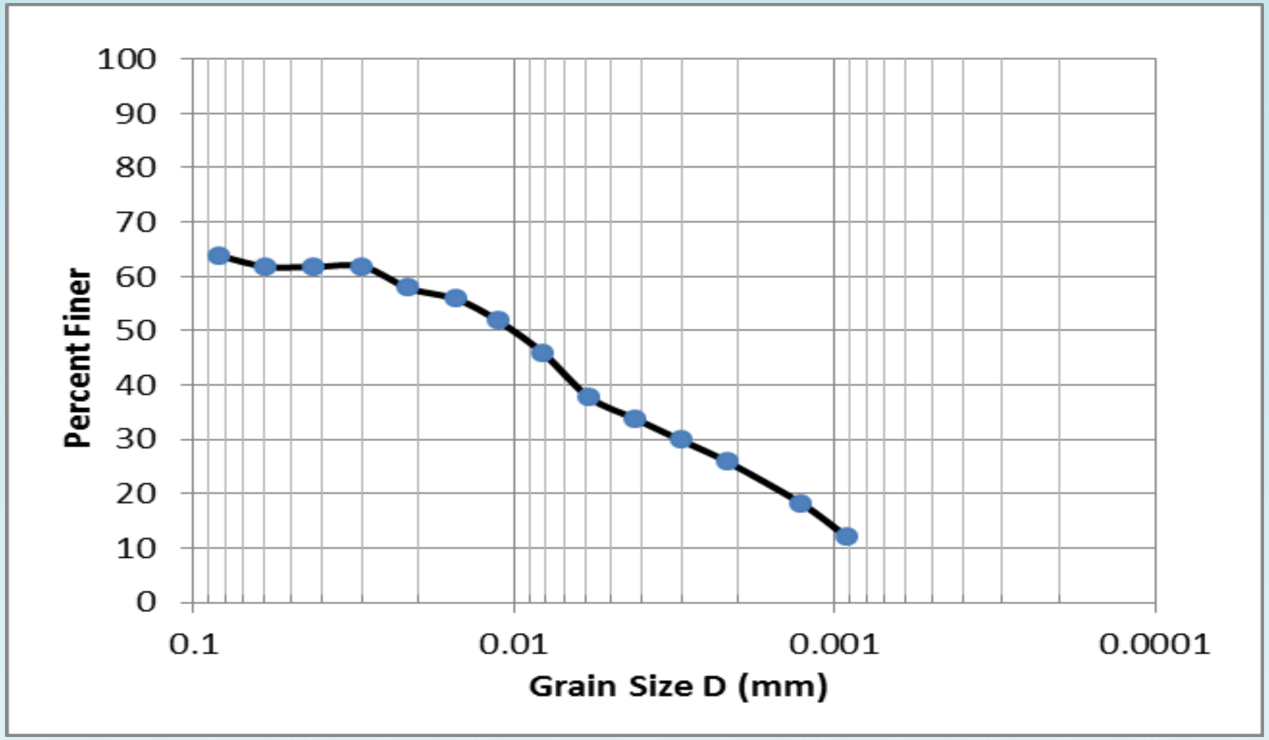
Heavy metal concentrations at port 100







Sediment Particle Size Distribution of Sediment



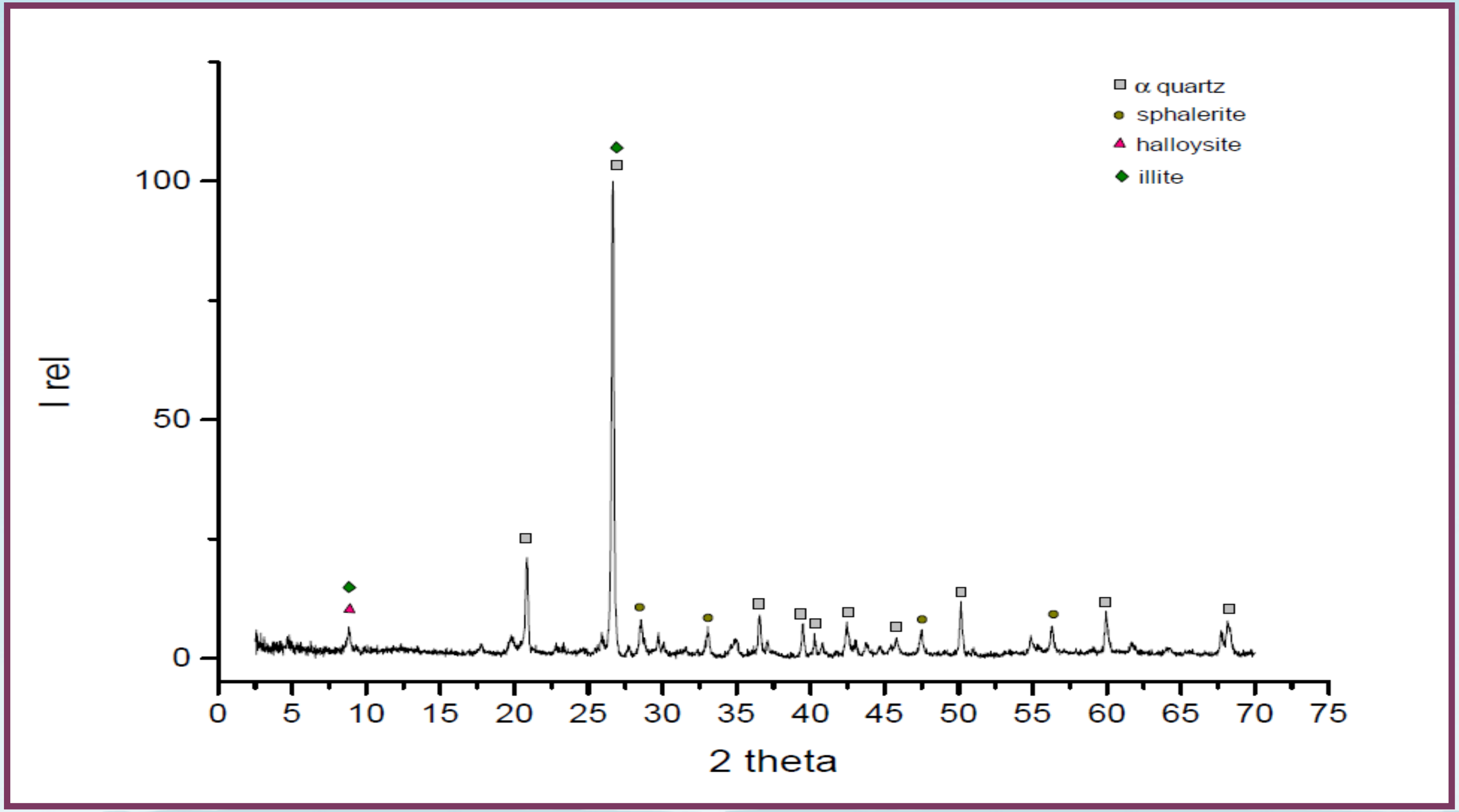
Diameter	Size
D10	≤ 0.005 µm
D50	≤ 0.020 µm
D90	≤ 0.035 µm

Heavy Metal Content of Sediments collected from SSGM Wastewater

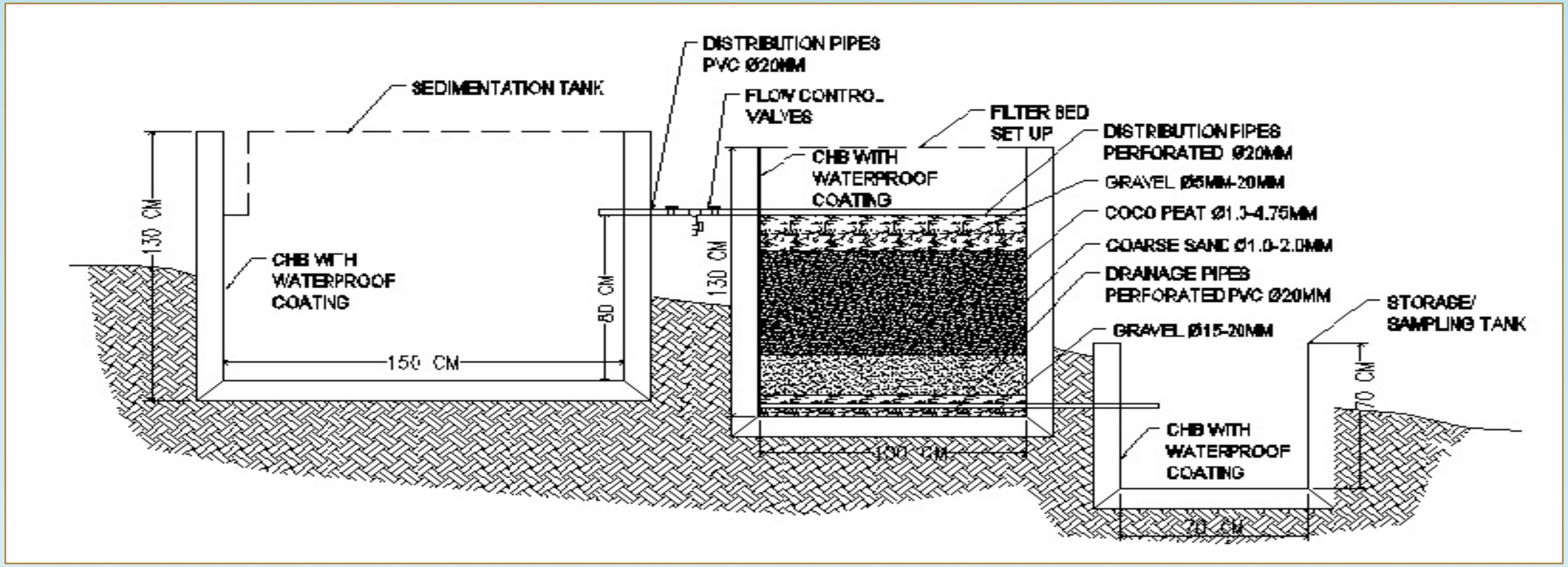
Sample	As (mg/kg)	Pb (mg/kg)	Hg (mg/kg)
Sed 1	0.005	0.64	0.0126

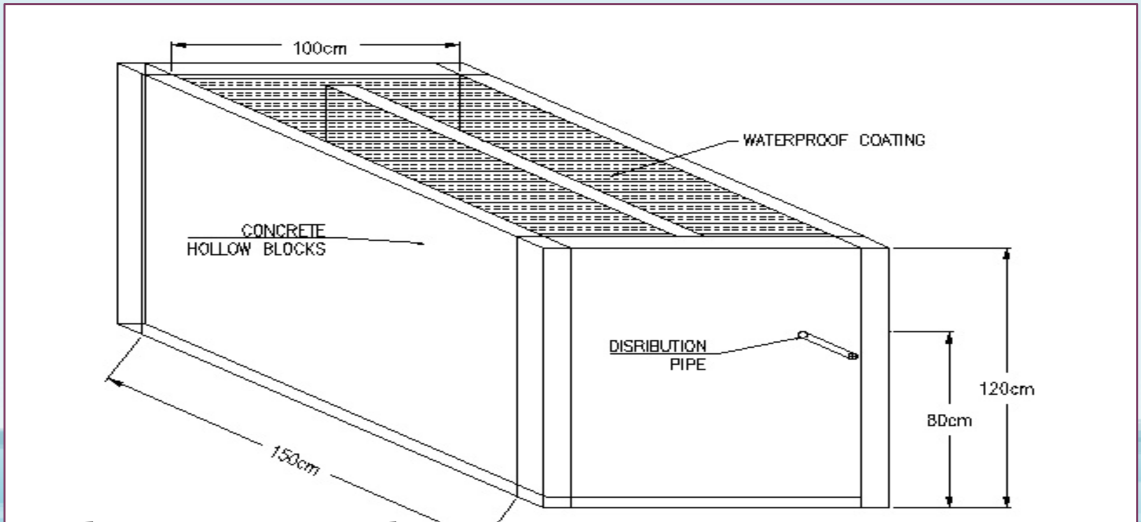
Research Output
Sedimentation

XRD Analysis of Sediment from SSGM Wastewater

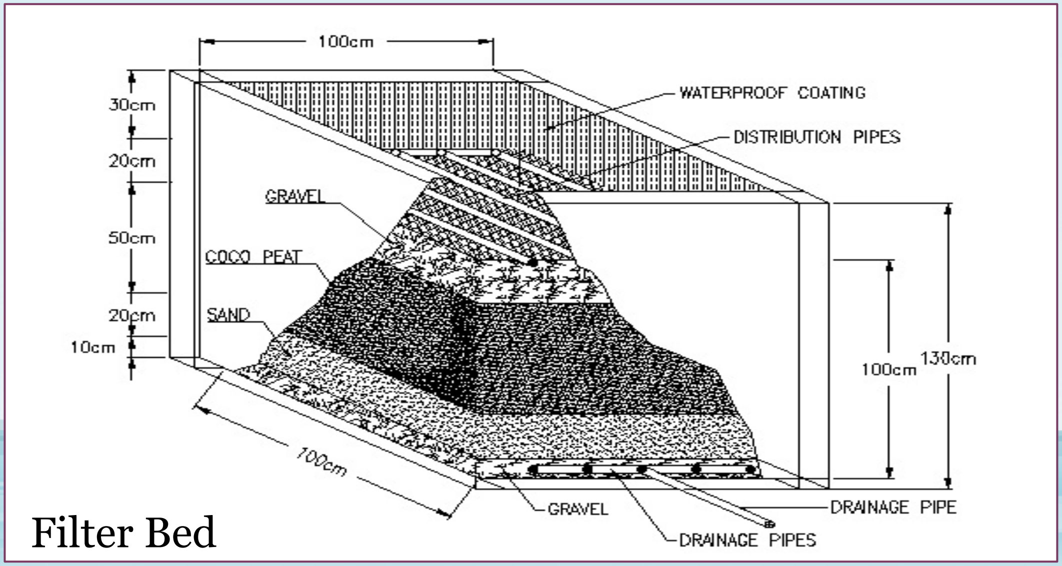


Design of Filter Bed System



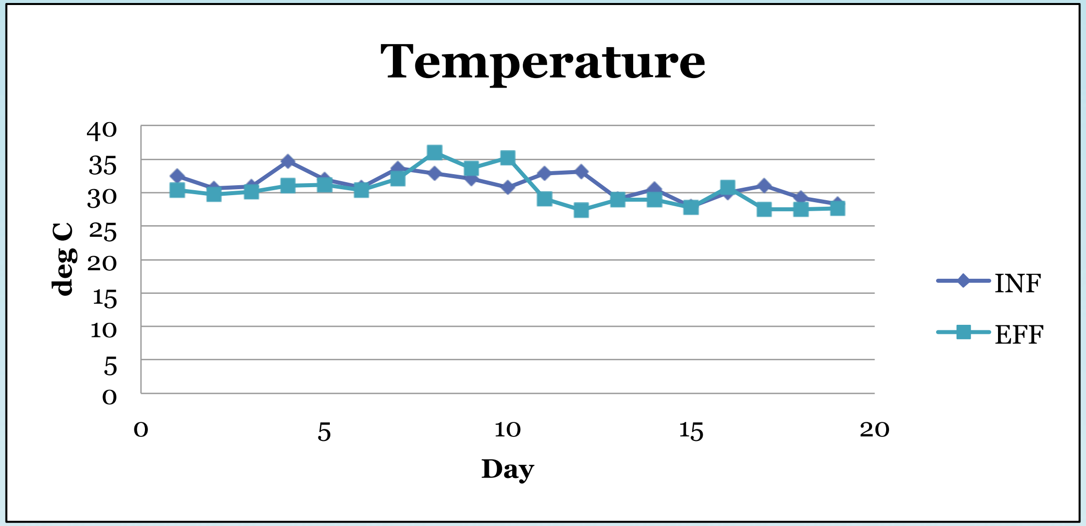


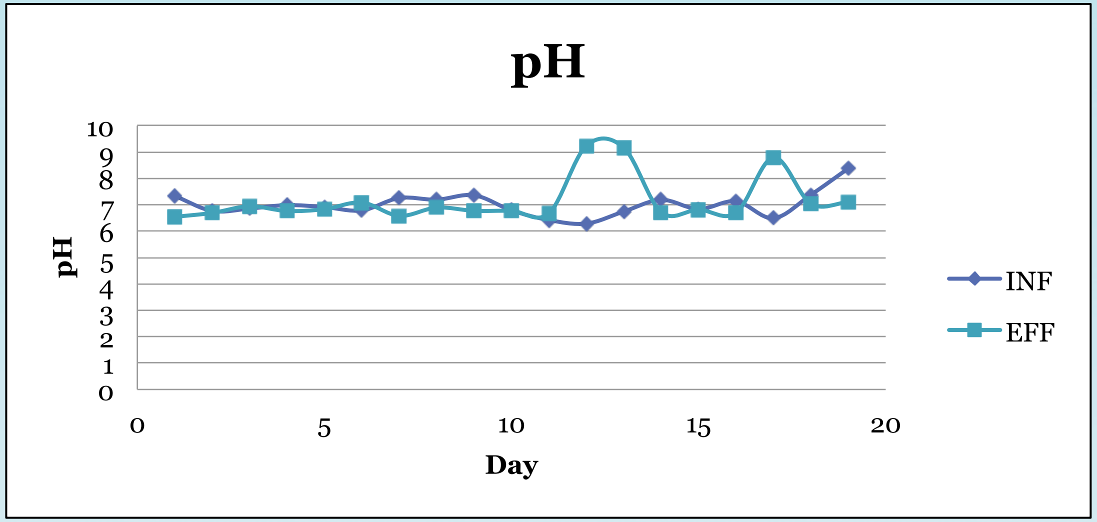
Sedimentation Tank

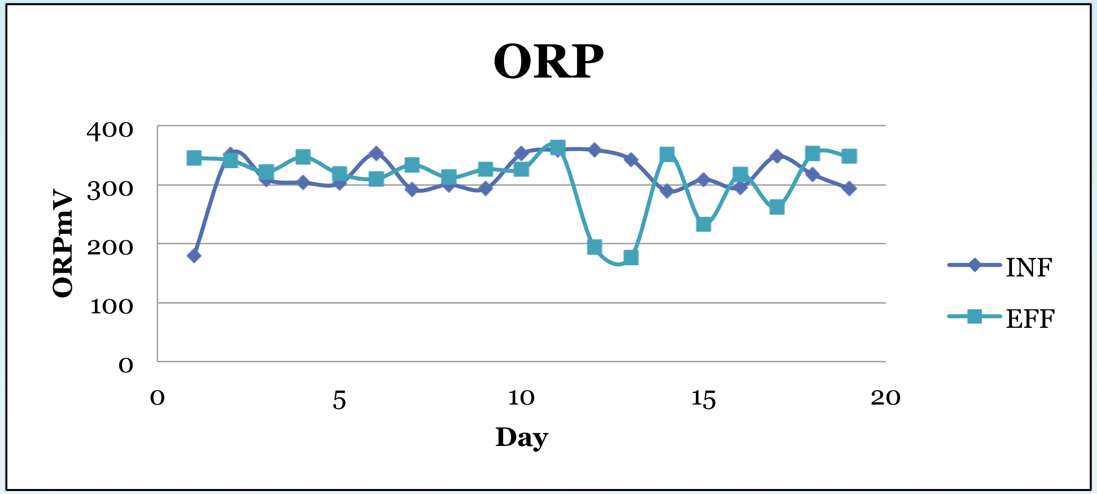


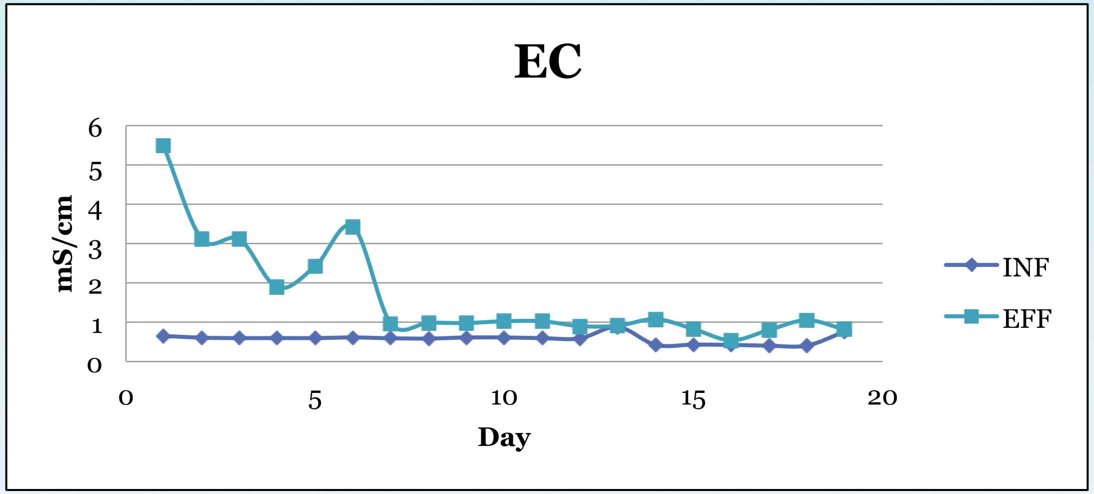
Filter Bed

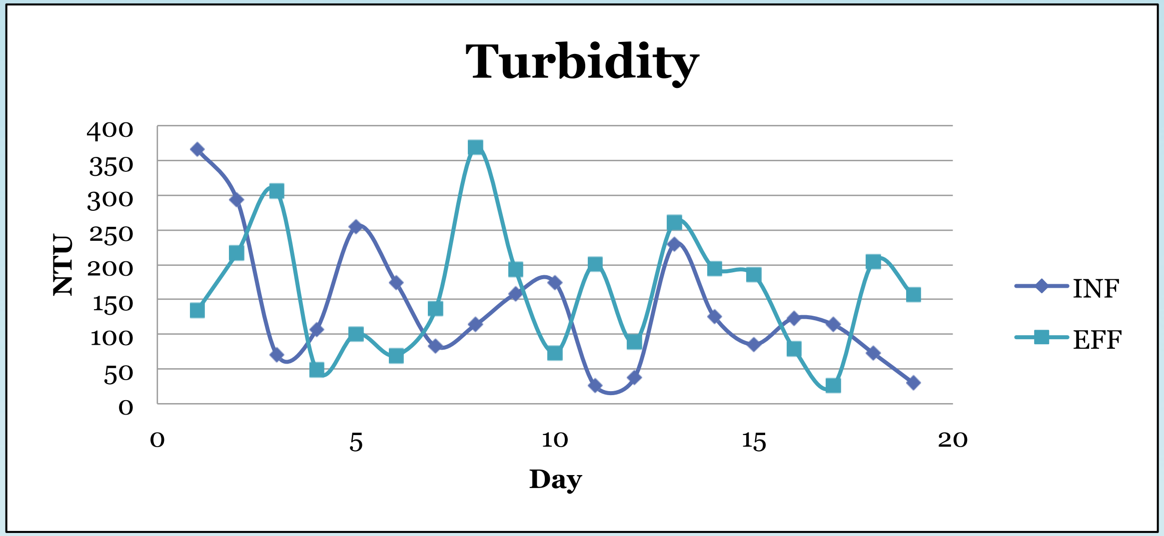
Construction of Filter Bed System

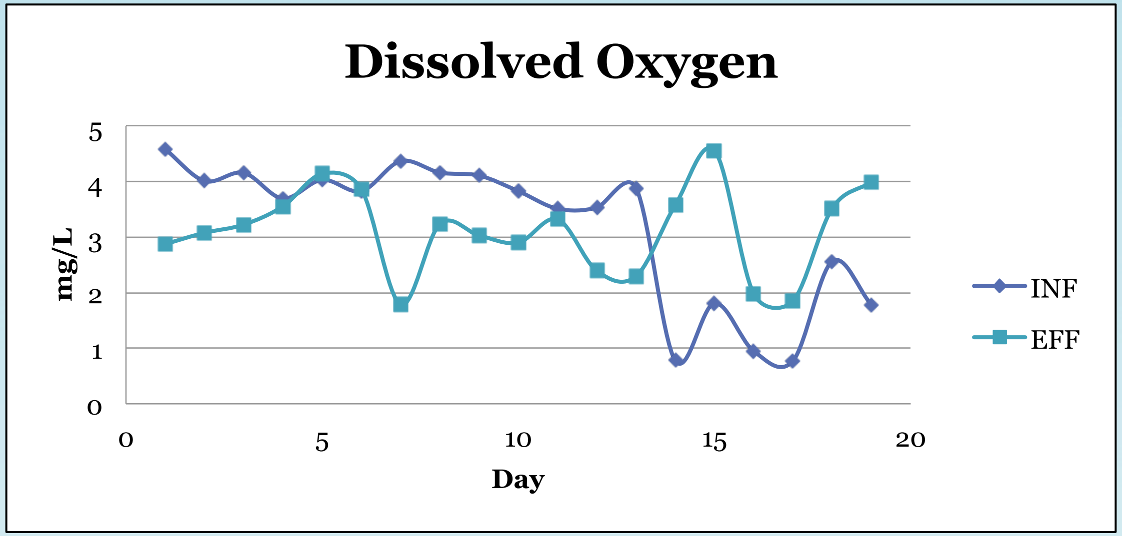

Temperature
40
35
30
25
20
15
10
5
0
deg C
0
5
10
15
20
Day
INF
EFF

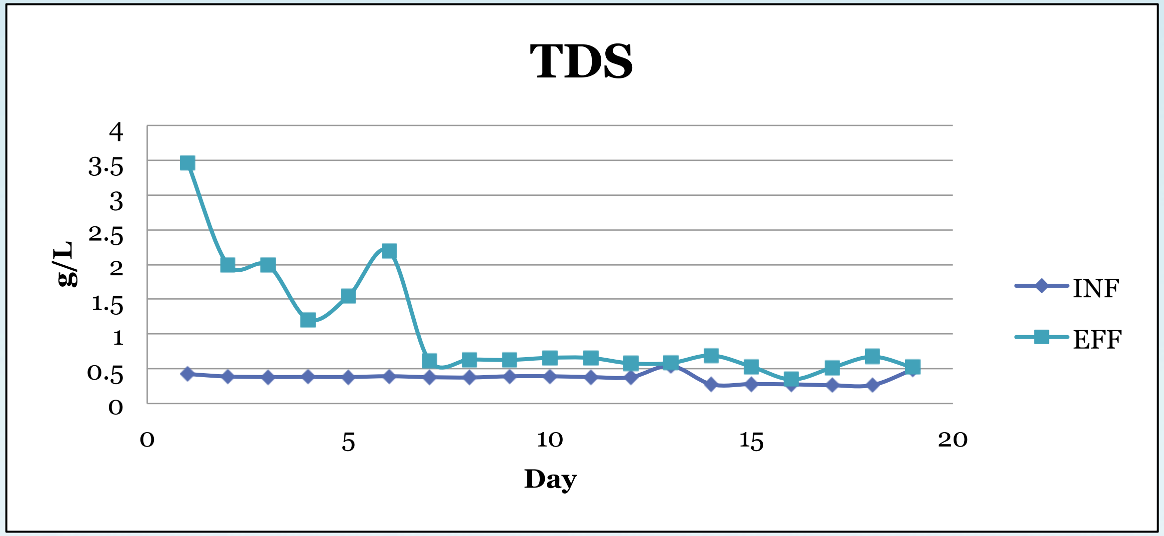

pH
10
9
8
7
6
5
4
3
2
1
0
pH
0
5
10
15
20
Day
INF
EFF

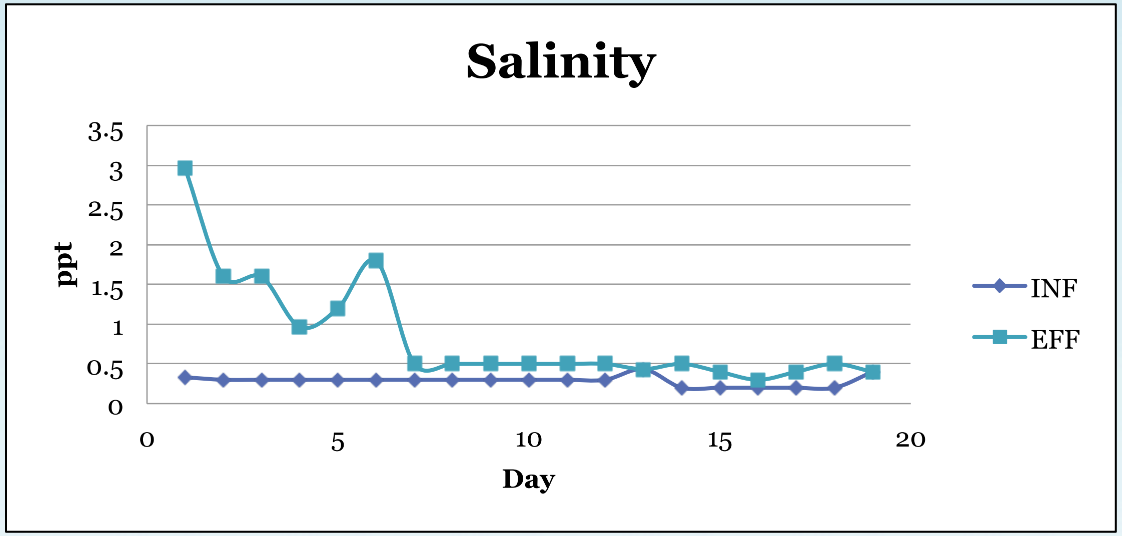

ORP
400
300
200
100
0
ORPmV
0
5
10
15
20
Day
INF
EFF

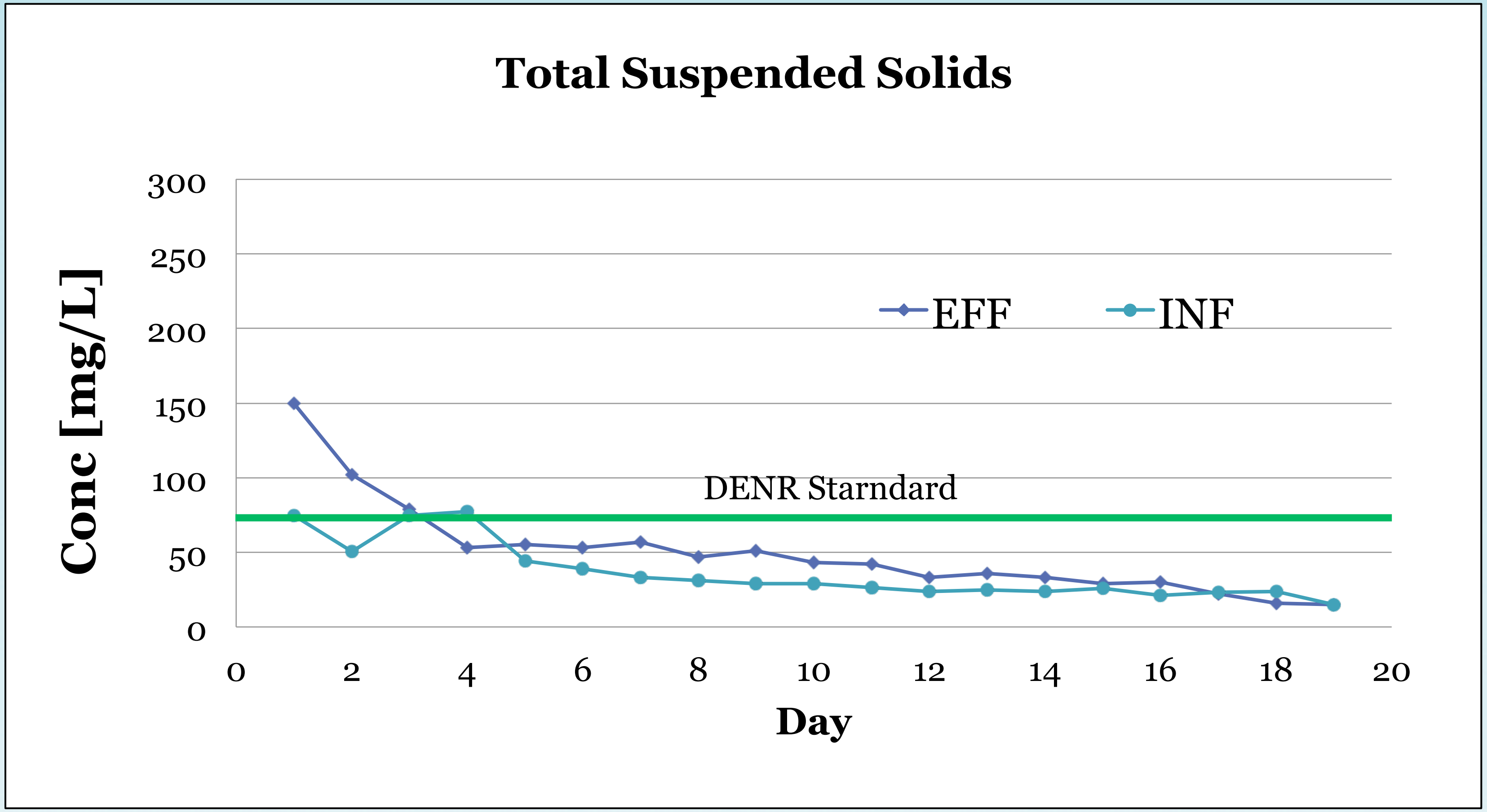

EC
6
5
4
3
2
1
0
mS/cm
0
5
10
15
20
Day
INF
EFF


Turbidity
NTU
400
350
300
250
200
150
100
50
0
0
5
10
15
20
Day
INF
EFF


Dissolved Oxygen
mg/L
5
4
3
2
1
0
0
5
10
15
20
Day
INF
EFF


TDS
g/L
4
3.5
3
2.5
2
1.5
1
0.5
0
0
5
10
15
20
Day
INF
EFF


Salinity
ppt
3.5
3
2.5
2
1.5
1
0.5
0
0
5
10
15
20
Day
INF
EFF



Total Suspended Solids
Conc [mg/L]
300
250
200
150
100
50
0
EFF
INF
DENR Starndard
0
2
4
6
8
10
12
14
16
18
20
Day

Influent Concentrations

Sample ID	As,ppm	Ba,ppm	Cd,ppm	Pb,ppm	Hg,ppm
INF 1	N.D.	0.0392	N.D.	N.D.	1.38
INF 2	N.D.	0.153	0.0025	N.D.	2.68
INF 3	0.0045	0.148	0.0043	N.D.	1.45
INF 4	N.D.	0.0973	0.0029	N.D.	1.01
INF 5	0.0024	0.0637	0.0022	N.D.	0.648
INF 6	0.0031	0.130	0.0038	0.0307	0.630
INF 7	0.0028	0.106	0.0030	N.D.	0.525
INF 8	0.0026	0.129	0.0038	N.D.	3.12
INF 9	0.0039	0.122	0.0041	N.D.	0.369

Note: N.D.- Not Detected

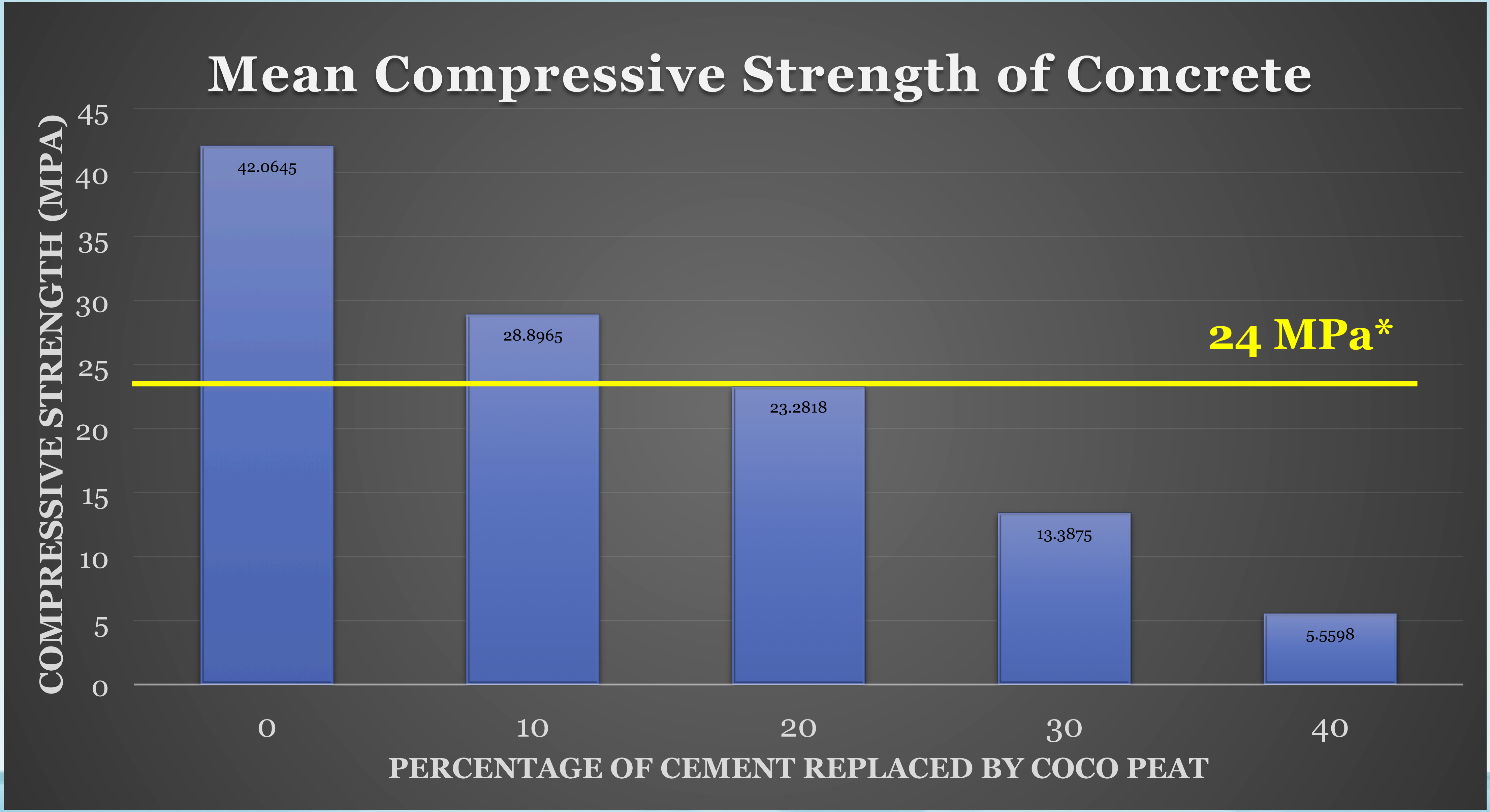
Effluent Concentrations

Sample ID	As,ppm	Ba,ppm	Cd,ppm	Pb,ppm	Hg,ppm
EFF 1	N.D.	0.537	N.D.	N.D.	0.274
EFF 2	N.D.	0.243	N.D.	N.D.	N.D.
EFF 3	N.D.	0.159	0.0017	N.D.	N.D.
EFF 4	N.D.	0.0888	N.D.	N.D.	N.D.
EFF 5	N.D.	0.0776	N.D.	N.D.	N.D.
EFF 6	N.D.	0.177	N.D.	N.D.	N.D.
EFF 7	N.D.	0.0866	0.0015	N.D.	N.D.

Note: N.D.- Not Detected

TCLP Results for Mortars with Different Cocopeat Percentage

	10%	20%	30%	40%	50%	DAO 29 Standard	Method Technique
As (mg/L)	<0.001	<0.001	<0.001	<0.001	<0.001	5	Hydride Generation - AAS
Ba (mg/L)	<0.20	<0.20	<0.20	<0.20	<0.20	100	Flame AAS
Cr (mg/L)	<0.02	<0.02	<0.02	<0.02	<0.02	5	Flame AAS
Cd (mg/L)	<0.003	<0.003	<0.003	<0.003	<0.003	5	Flame AAS
Pb (mg/L)	<0.01	<0.01	<0.01	<0.01	<0.01	5	Flame AAS
Hg (mg/L)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.2	Cold Vapor - AAS
Se (mg/L)	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	1.0	Hydride Generation - AAS



*ASTM C387/C387M

Acknowledgement

Department of Science and Technology – Philippine Council for Industry, Energy and Emerging Technologies Reseach and Development (PCIERD)

Engineering Research and Development for Technology (ERDT)

Thank you for your attention.