SLUDGE ACCUMULATION IN STABILISATION PONDS IN THE SOUDANO-SAHELIAN CLIMATE OF BURKINA FASO

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INTRODUCTION

Wastewater stabilization ponds (WSP)

- Low cost
- Low operation and maintenance
- Sanitary efficiency

WSP most adapted for developping countries

particularly in Subsaharian Africa

Sufficient land available **Temperature favorable**

INTRODUCTION

- With the scarcity of water resources and the increase of the irrigation demand, the reuse of wastewater is encouraged and the construction of wastewater stabilisation ponds in in the capitals of sub Saharan countries are currently relevant.

- A future increase in the number of WSPs is naturally expected, and sludge production and its management are also expected to increase.

- Sludge accumulation represent a reservoir of organic substances and can be a problem after several operation years by impacting ponds performances, altering the pond's hydraulics due to a decrease in the pond's effective volume.

INTRODUCTION

Little research has been conducted in soudano-sahelian climate conditions to study sludge accumulation in WSPs

The goal of this research is to contribute to the **understanding** of sludge **accumulation rates** in different types of ponds, to produce a **useful database for sludge accumulation** and that can be used for pond **successful operations** and **maintenance taking in count of local data basis**

Accumulation rate of sludge must be known so that the frequency of sludge removal can be determined and integrated into the pond design, and maintenance schedule.

MATERIALS AND METHODS

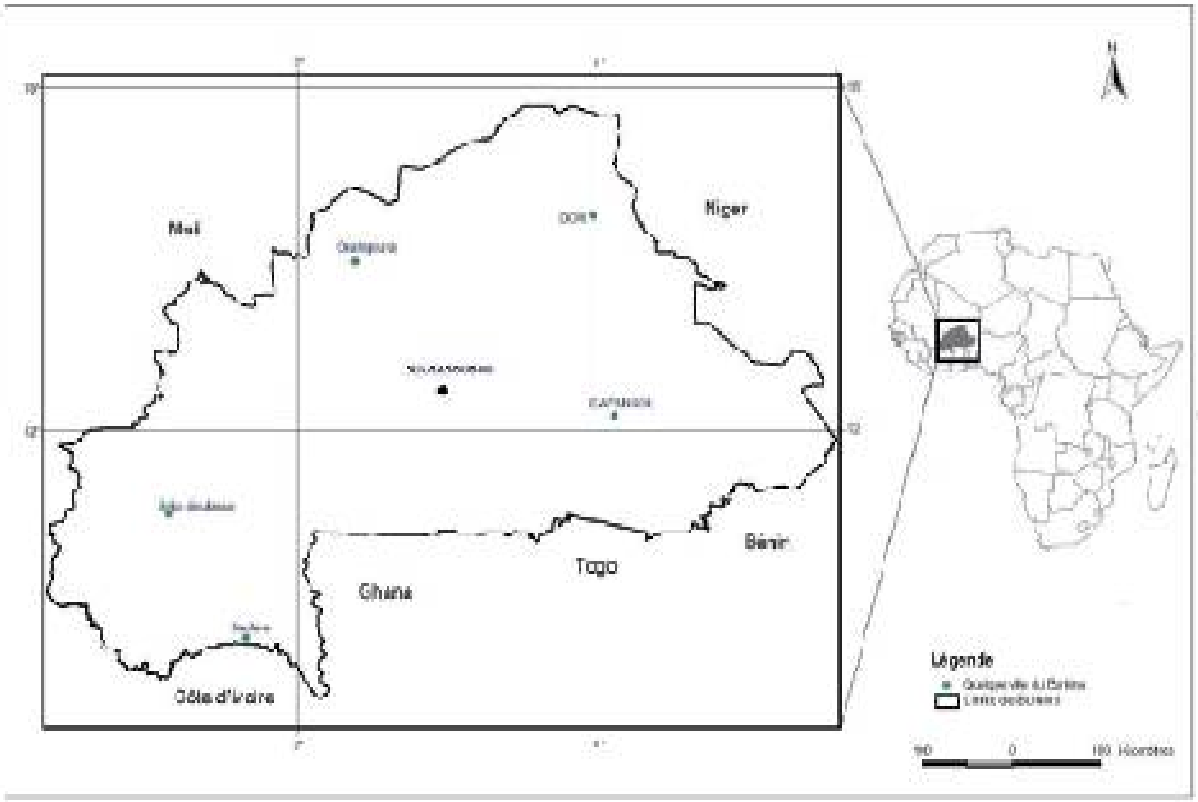
This work was carried out at the pilot scale wastewater stabilization pond system of 2iE campus, Ouagadougou, Burkina Faso.

Soudano sahelian climate:

Long dry season (oct-May)

Solar energy 2500h/year
19.5-22.7 MJm-2d-1

Rainy season June – september, 600 to 900 mm



Montly average T° of the coldest month: 25 to 26°C
Maximun T°42°C in april
Minimum T° 16°C in january

MATERIALS AND METHODS

Wastewater stabilization pond system of 2iE campus, Ouagadougou, Burkina Faso.

Three ponds in series: Anaerobic Pond (AP), Facultative Pond (FP) and Maturation Pond (MP)

Organic load = 389 PE

AP: Depth = 2.6m; V= 107m3;
HRT=3 d

FP: Depth = 1.4m; V= 433m3
HRT = 9.5 d

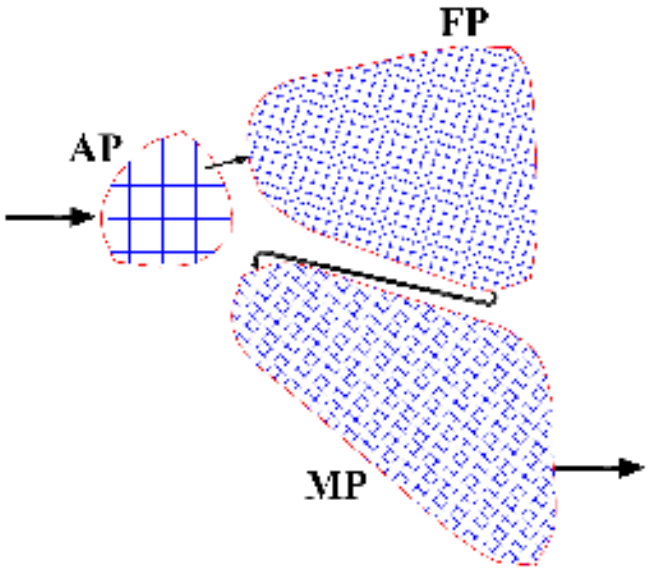
MP: Depth = 0.9 m; V= 236m^3
HRT= 5.5 d

MATERIALS AND METHODS

Sludge accumulation was measured by bathymetric surveys using a pre-prepared grid of the ponds

The ponds were divided into bathymetric sections spaced by **1 *m* for the anaerobic** pond, and **by 2 *m* for the facultative and the maturation ponds**, with longitudinal and transverse string lines placed on the surface of each pond.

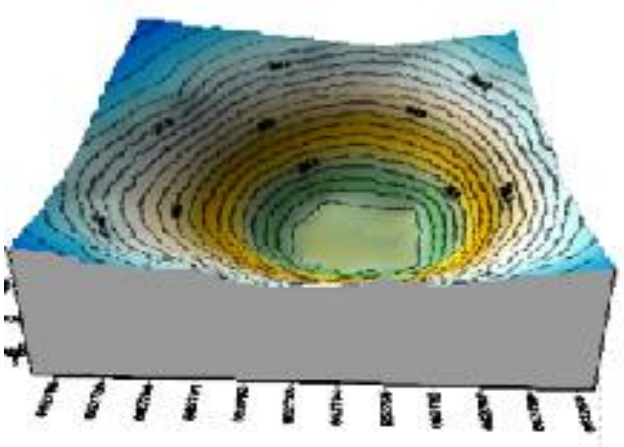
Sludge depths were measured using the **white towel test technique** described by Mara (2004)



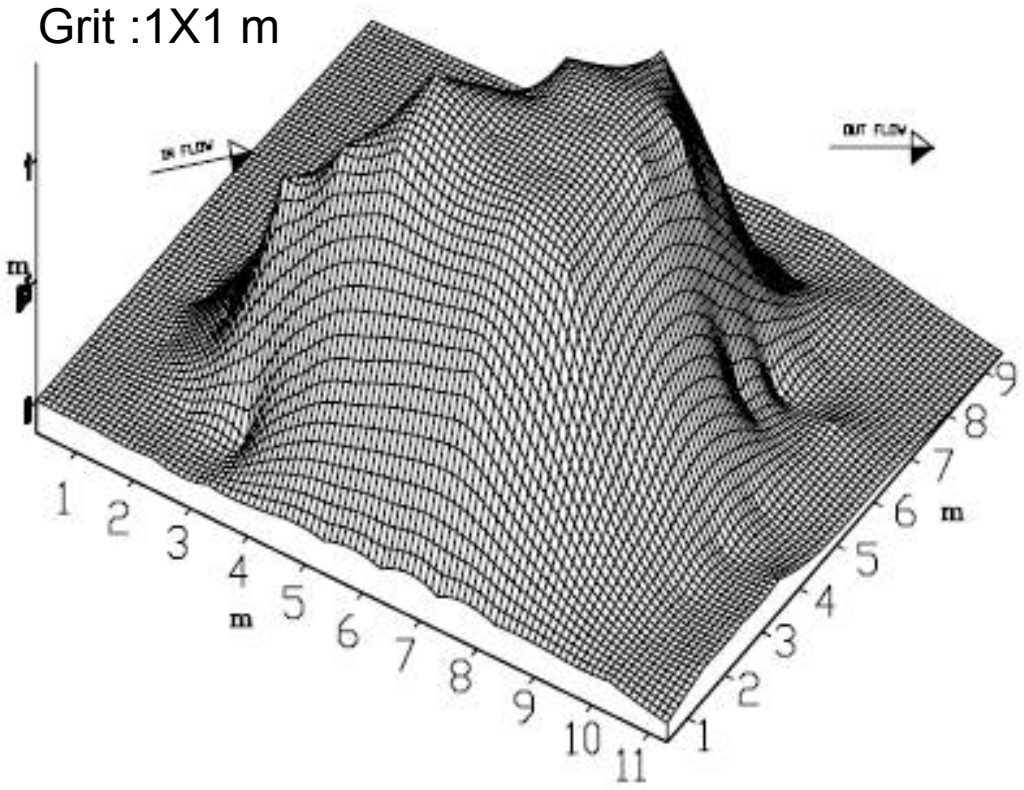
RESULTS AND DISCUSSION
Sludge distribution in the Ponds

The three-dimensional surface profiles of the sludge distribution in the ponds were established by Surfer software (Version 7.00)

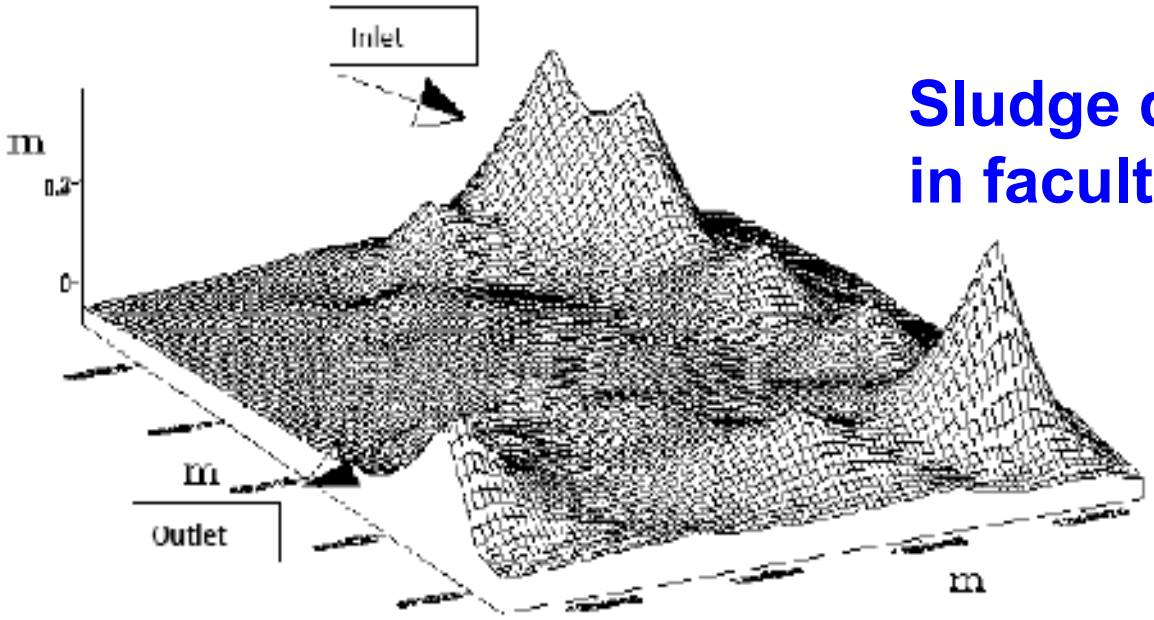
Distribution of sludge in the anaerobic pond



Grit :1X1 m



In AP, the pattern of distribution of sludge seems to be linked to the geometric form of the pond (cylinder-cone)

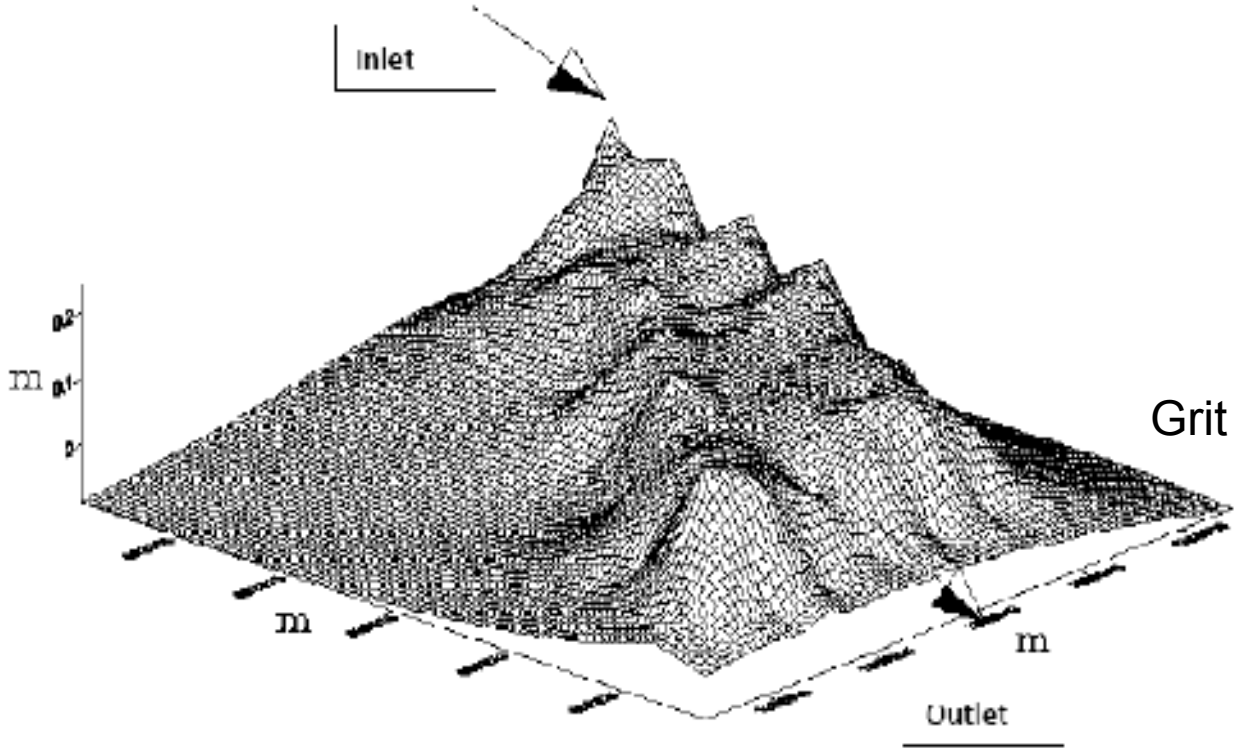


Sludge distribution in facultative pond

Grit :2X2 m

- Sludge distribution in FP was uneven
- Maximum sludge thickness occurred near the inlet
- Higher accumulation also occurred in some of the corners and near the outlet of ponds
- Similar observations have been reported by Nelson et al. (2004) in a study of sludge accumulation in Mexico
- The accumulation in the corners seems to be more linked to the wind direction; the trapezoidal form of pond can also favour the accumulation at the sides of pond.

Sludge distribution in maturation pond



Grit :2X2 m

The distribution of sludge in maturation pond is almost similar as those observed in the facultative pond

SLUDGE ACCUMULATION IN PONDS

POND	Age (year)	Accumulation Rates		
		(cm/year)	m^3/capita.year	Kg dw/capita year
ANAEROBIC	5.5	-	0.020	1.30
FACULTATIVE	5.5	1.59	0.009	0.43
MATURATION	5.5	1.3	0.007	0.26

Sludge accumulation rates in AP (m^3/capita year) reported in the literature:

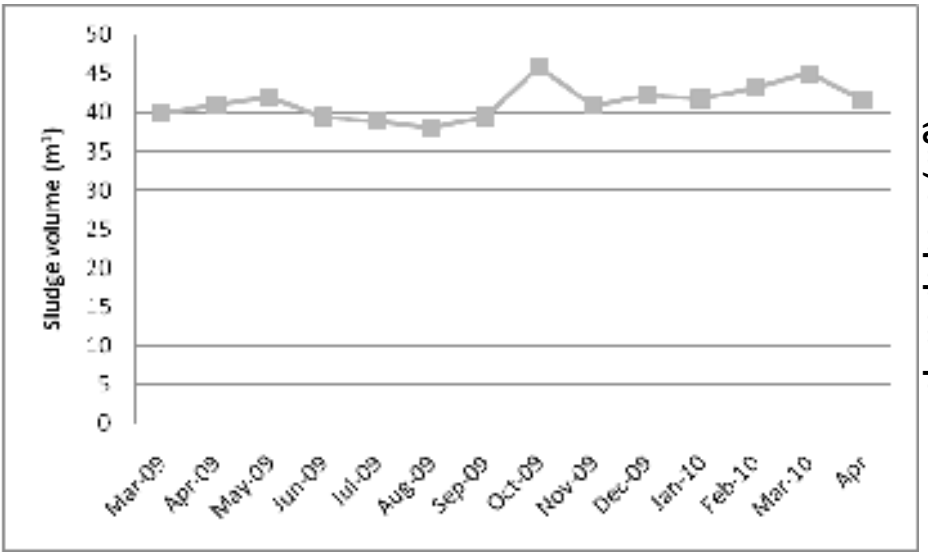
Sevilla Spain (Salas and Bouza (2011)	French Méditerranean (Picot et al 2003)	Central Mexico (Nelson et al 2004	Warm climate (Mara et al 2004)	Columbia Pena *et al* (2000)
0.011	0.017-0.028	0.022	0.04	0.04 -0.05

Sludge accumulation rate in AP (1.30 Kg dw/capita year) is far lower than average rate (8 kg dw/capita year) measured in 19 primary facultative ponds in France (Picot et al 2005), due to degradation of sludge by methanisation in anaerobic ponds.

Sludge accumulation in AP

Under soudano sahelian climatic conditions:

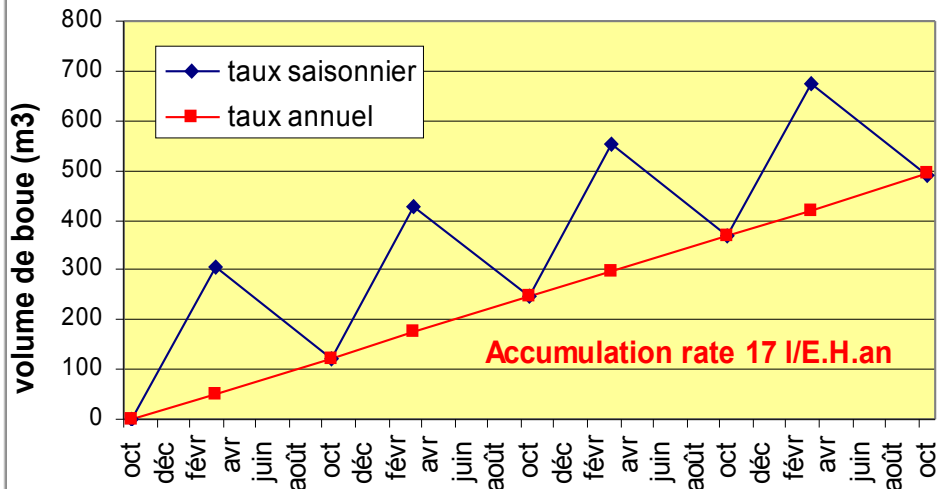
No seasonal fluctuation



Warm conditions during the year explain a continuous digestion of sludge during their accumulation

Under mediterranean climatic conditions:

Seasonal fluctuation



The accumulation of sludge followed annual sinusoidal pattern with high values during winter and low ones during summer due to increased digestion rate.
(Picot et al 2003 and Papadopoulos 2003)

SLUDGE ACCUMULATION IN PONDS

Burkina Faso Ponds	Age (year)	Accumulation Rates		
		(cm/year)	m^3/capita.year	Kg dw/capita year
ANAEROBIC	5.5	-	0.02	1.30
FACULTATIVE	5.5	1.59	0.009	0.43
MATURATION	5.5	1.3	0.007	0.26

- The accumulation rates in FP and MP were found lower than in AP.

- The percent of pond volume occupied by sludge in the FP and MP (4,5% and 6,5 respectively) is very low, which is to be expected since the vast majority of sludge removal occurred in the primary anaerobic pond

Characteristics of sludge

Parameters	AP	FP	MP
Density	**1,1** [1,01-1,13]	**1,01** [1,01-1,03]	**1,01** [1,01-1,102]
Water content %	**93,9** [86,9 - 99,7]	**95,3** [92,9-99,8]	**96,4** [89,1- 99,7]
Total solids g/l	**61,3** [3,4 - 132,7]	**46,5** [16,1- 125,7]	**35,5** [2,2 - 110,9
Fixed solids (%TS)	**50,6** [28,3 - 80,5]	**58,2**[37,4 - 83,5]	**67,1** [35 - 81,9]
Volatile solids (%TS)	**49,4** [19,5 - 71,7]	**41,7** [16,5-62,6]	**32,9** [18,1 - 65]

SLUDGE MODEL CALIBRATION IN ANAEROBIC POND

Saqqar and Pescod 1995

$$V_{AS} = K_{AS} (1.7\ F_{XVSS} + 4.5F_{XFSS} + F_{BOD5})/1000$$

V_{AS} = Volume of sludge accumulated (m^3/year)
F_{XVSS} = Mass input rates of volatile suspended solids at the pond inlet (kg/year)

} Measured on raw wastewater

F_{XFSS} = Fixed suspended solids (kg/year)
F_{BOD5} = Total BOD5 at the pond inlet (kg/year)
K_{AS} = Biodegradability rate of the settled sludge or digestion rate
the lower the value, the higher the biodegradability of settled sludge

SLUDGE MODEL CALIBRATION IN ANAEROBIC POND

In our study in soudano-sahelian climate of Burkina Faso, the biodegradability rate of sludge in anaerobic pond was calculated to be : K_{AS} = 0.38

The model of annual sludge accumulation for anaerobic pond in soudano-sahelian climate conditions is :

$$V_{AS} = 0.38\ (1.7\ F_{XVSS} + 4.5 F_{XFSS} + F_{BOD5})/1000$$

The biodegradability value found in our study was lower than that reported by Saqqar and Pescod (K_{AS} = 0.6), and much lower than that reported by Paing et al (2000), and Papadopoulos et al (2003) (K_{AS} = 1.4).

The high temperature in soudano-sahelian climate of Ouagadougou induces a high biodegradation of settled sludge mainly by methanisation.

CONCLUSION

This study has provided useful data on sludge distribution and accumulation in three types of ponds (anaerobic, facultative, maturation) in soudano-sahelian climate conditions.

The distribution of sludge accumulation in facultative and maturation pond was found to be uneven. Maximum sludge thickness occurred near the inlets, the outlets and at some corners.

After 5,5 years of continuous operation, sludge accumulation represented as reduction of useful volume of 38,7%, 4,5% and 6,5% respectively for the anaerobic, facultative and maturation.

According to Mara and Pearson(1998), they suggest that anaerobic ponds require desludging when they are around one-third full of sludge (by volume).

In this respect, the desludging interval of the anaerobic pond was calculated to be 5 years. In the same way, the desludging intervals of facultative and maturation ponds were calculated to be respectively 40 and 28 years.

CONCLUSION

After 5.5 years of operation the rate of sludge accumulation in anaerobic pond was estimated to 0.020 m^3/capita- year.

The net sludge accumulation was calculated to be 1.30 kg/ capita-year, 0.43 kg/ capita-year and 0.26 kg/ capita-year respectively in anaerobic, facultative and maturation ponds.

These rate could help the designers and operating staff to predict and to planify how long it will be necessary to desludge different types of ponds in order to do not affect their treatment efficiencies.


Thank you for your attention
Gratias