

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

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Abstract

Three types of ponds used for treating domestic wastewater in Burkina Faso in Soudano-sahelian climate, were monitored for sludge accumulation. After five and a half years of operation, the rates of sludge accumulation in the ponds were evaluated to 0.02; 0.009 and 0.007 m³/capita year respectively for the anaerobic, facultative and maturation ponds. The corresponding rates of accumulation in dry weight (dw) per person per year were calculated to 1.3, 0.43 and 0.26 kg dw/capita year respectively in anaerobic, facultative and maturation ponds. A coefficient of high biodegradability of sludge was found in the anaerobic pond.

Keywords: Sludge, Accumulation, Waste stabilization pond, Burkina Faso.

INTRODUCTION

Developing countries, particularly those of Sub-Saharan Africa such as Burkina Faso, have been characterised by low indices of wastewater treatment. Among processes considered to be suitable for these warm parts of the world, Wastewater Stabilisation Ponds (WSPs) seem to constitute an appropriate and sustainable solution. With the scarcity of water resources and the increase of the irrigation demand, the reuse of wastewater are encouraged the government of the Burkina Faso to accelerate the construction of wastewater stabilisation ponds in the principal towns. This example illustrates a sustainable management of municipal wastewater and similar projects of construction of WSPs in the capitals of sub Saharan countries are currently relevant. A future increase in the number of WSPs is naturally expected. As a consequence, amount of sludge produced and the need for its management are also expected to increase. Sludge management of WSPs includes periodic removal followed by disposal or reuse. Up to now, little research has been conducted in soudano-sahelian climate condition to study sludge accumulation in WSPs.

The goal of this research is to contribute to our understanding of sludge accumulation rate in different type 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.

MATERIALS AND METHODS

This work was carried out at the pilot scale wastewater stabilization pond system (12°22' N, 1°30'W) of the International Institute for Water and Environmental Engineering (2iE) of Ouagadougou, Burkina Faso. More details on the climatic conditions of the site are described in a previous study (Konate et al, 2010).

The wastewater treatment system consists of three ponds connected in series: (one anaerobic pond with 2.6 m depth, one facultative pond with 1.4 m depth, and one maturation pond with 0.9 m depth). The wastewater originates from the 2iE campus passes through a bar screen for pretreatment before it enters the primary anaerobic pond. This pond has a vertical geometric form of a cylinder-cone (with a useful volume of 107 m³ while the facultative (433 m³ of useful volume) and maturation ponds (236 m³ of useful volume) are of trapezoidal form. The three ponds had been in continuous operation for 5.5 years (from October 2004 to April 2010). The anaerobic pond received an equivalent organic load of 389 PE

Sludge depth were measured during punctual bathymetric surveys of the distribution of sludge in the three ponds at September 2008, and monthly bathymetric surveys were measured from march 2009 up to April 2010. 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. The bathymetric survey was accomplished by the placement of longitudinal and transverse string lines placed on the surface of each pond. Pond depth and sludge thickness were measured at a total of 84 for the anaerobic pond, 95 for the facultative pond, and 105 for the maturation pond. At each coordinate, sludge depth was measured using the white towel test technique described by Mara (2004)

RESULTS AND DISCUSSION

During four the first years of service, the anaerobic pond was functioning with an equivalent organic load of 448 PE. During the last 1.5 years, a movement of the staff service and student on another campus caused a decrease of the flows and loads admitted in the anaerobic pond, receiving an equivalent of organic of 232 PE, giving a global equivalent organic load on the 5.5 years operation to 389 PE,

A previous study (Konate et al, 2010) detailed the accumulation pattern in the anaerobic pond after four years of continuous operation. The unique geometric form (cylinder-cone) of the anaerobic pond in this study did not affect the pattern of sludge distribution as compared to trapezoidal ponds reported in the literature. 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 ponds. 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 4,75 years. In the same way, the desludging intervals of facultative and maturation ponds were calculated to be respectively 40 and 28 years.

The distributions of sludge in the ponds are given in Figure 1, which shows that the distribution of sludge was uneven. The maximum sludge thickness occurred near the inlets; higher accumulation also occurred in some of the corners and near the outlets of ponds. Similar observations have been reported

by Nelson et al. (2004) in a study of sludge accumulation in central Mexico. The accumulation in the corners in our case seems to be more linked to the wind direction; the trapezoidal form of ponds can also favour the accumulation at the sides of ponds.

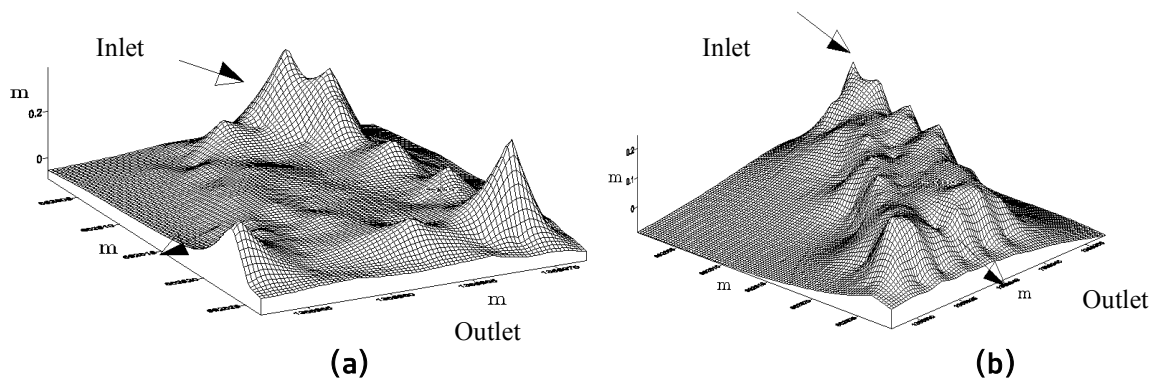


Figure 1: Sludge distribution in the Facultative Pond (a) and Maturation Pond (b)

The per capita accumulation rates on a volumetric and dry weight basis are given in Table 1 for the three ponds. For the anaerobic pond, the accumulation rate of $0.02 \text{ m}^3/\text{capita year}$ was lower than those reported by Mara *et al* (2004) of $0.04 \text{ m}^3/\text{capita year}$ in warm climates, the value of $0.05 \text{ m}^3/\text{capita year}$ reported by Pena *et al* (2000) in Colombia, and the value of $0.0519 \text{ m}^3/\text{capita year}$ reported by Gonçalves *et al* (2002) in Brazil. In the facultative and maturation ponds at 2IE, the per capita values were calculated to be respectively 0.009 and $0.007 \text{ m}^3/\text{capita year}$. Because of these low accumulation rates, the percent of pond volume occupied by sludge is very low, which is to be expected since the vast majority of sludge removal occurred in the primary anaerobic pond.

For the anaerobic pond, the annual accumulation of sludge was evaluated to be $7.5 \text{ m}^3/\text{year}$. According to a model developed by Saqqar and Pescod (1995), the volume of sludge accumulated (V_{AS}) in a primary anaerobic pond was expressed in terms of the mass input rates of volatiles suspended solids (F_{XVSS}), Fixed suspended solids (F_{XFSS}) and total BOD5 (F_{BOD5}) in the raw wastewater and accumulated sludge coefficient (K_{AS}) with following equation: $V_{AS} = K_{AS} (1.7 F_{XVSS} + 4.5 F_{XFSS} + F_{BOD5}) / 1000$. K_{AS} represented the biodegradability rate of the settled sludge, the lower the value, the higher the biodegradability of settled sludge. In our study in soudano-sahelian climate, the biodegradability of sludge of the anaerobic pond was calculated to be: $K_{AS} = 0.38$. This value 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 by methanisation.

Table 2: Sludge accumulation rates

Pond	Age (year)	Accumulation rate		
		cm/year	m ³ /capita.year	Kg dw/capita.year
AP	5.5	-	0.02	1.30
FP	5.5	1.59	0.009	0.43
MP	5.5	1.3	0.007	0.26

CONCLUSION

- This study has provided useful data on sludge accumulation in three types of ponds (anaerobic, facultative, maturation) in soudano-sahelian climate conditions. 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.
- The annual accumulation rate of sludge in pond decreased with the age of sludge, especially for the anaerobic pond where the high temperature of soudano-sahelian climate leads to a high biodegradation of sludge by methanisation.

REFERENCES

- Gonçaves R.F. (2002) Recycled sludge thickening and digestion pond from physicochemical upgrading process of facultative pond effluent. *Proceeding 5th International IWA Specialist Group Conference on Waste Stabilization Ponds, Pond Technology for the New Millennium, Auckland- New Zealand.*
- Konate Y., Maiga A.H., Wethe J., Basset D., Casellas C., and Picot B. (2010). Sludge accumulation in anaerobic pond and viability of helminth eggs: a case study in Burkina Faso. *Water Science and Technology* **61**(4) 919–925
- Mara D.D (2004). *Domestic Wastewater treatment in developing countries*, Earthscan Publications, London.
- Nelson K.L. Cisneros B.J. Tchobanoglous G. and Darby J.L. (2004). Sludge accumulation, characteristics, and pathogen inactivation in four primary waste stabilization ponds in central Mexico. *Water Research*, **38**, 111–127.
- Paing J., Picot B., Sambuco J., Rambaud A., Sludge accumulation and methonogenic activity in anaerobic lagoon *Water Science and Technology*, 42(10–11) 47–55.
- Papadopoulos A., Parisopoulos G., Papadopoulos F., Karteris A. (2003) Sludge accumulation pattern in an anaerobic pond under Mediterranean climatic conditions. *Water Research*, **37** 634–644.
- Pena M. Mara D.D. and Sanchez A. (2000). Dispersion studies in anaerobic ponds: implications for design and operation. *Water Science and Technology*, **42**(10) 273–282.
- Picot B., Sambuco J.P., Brouillet J.L., Rivière Y. (2005). Wastewater stabilisation ponds: Sludge accumulation, technical and financial study on desludging and sludge disposal. Case studies in France. *Water Science and Technology*, **51**(12), 227–234.
- Von Sperling, M., Chernicharo C.A.L. (2005) Biological wastewater treatment in warm climate regions. Volume Two, *IWA publishing*, Alliance House, 12 Caxton Street, London SW1H 0QS
- Saqqar M.M. and Pescod M.B. (1995) Modelling sludge accumulation in anaerobic wastewater stabilisation ponds *Water Science and Technology*, **31** (12), 185–190