Sludge treatment for sewage sludge of an activated sludge wastewater treatment plant in Montenegro using sludge drying reed beds

This paper presents the design of sludge drying reed beds for sewage sludge of an activated sludge wastewater treatment plant with a load of 2500 PE in Montenegro.

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Abstract

As an alternative to an existing sludge treatment system in the form of a belt filter press at an activated sludge wastewater treatment plant of the municipality of Mojkovac in Montenegro sludge drying reed beds were designed, aiming at simplifying operation of the sludge treatment system as well as at improving the quality of the sludge before reuse. The project was also designed as a pilot system for the Ministry of Sustainable Development and Tourism with the support of UNIDO in order to gain more experience and knowledge on sludge drying reed beds for sludge treatment in Montenegro.

Introduction

Sewage sludge generated in wastewater treatment plants, comprising primary sludge from mechanical pre-treatment as well as surplus sludge from biological treatment, requires further treatment for a number of reasons. On the one hand depending on the wastewater treatment process the sludge has to be stabilised and depending on the planned reuse or disposal option reduced in volume. These objectives may be achieved by a number of different technical options. Sludge drying reed beds have been applied for more than 20 years as an option requiring low operation and maintenance cost. The municipality of Mojkovac in Montenegro is operating an activated sludge wastewater treatment plant for app. 2´500 PE. Primary and surplus sludge are first reduced in water content in a static thickener and should then be dewatered using belt filter presses. For technical reasons – a too small pipeline from the sludge thickener to the feed pumps for the belt filter presses – as well as the planned reuse of the treated sludge, the Municipality of Mojkovac, together with the Ministry of Sustainable Development and Tourism with the support of UNIDO decided to design and implement sludge drying reed beds for the treatment of the sludge of the wastewater treatment plant.

Process Description

Sludge drying reed beds use common reed (*Phramites australis*) which is planted into a substrate layer on top of a substrate / drainage system. The reed penetrates the layers of sludge which are fed intermittently into the sludge drying reed bed and increases dewatering. An annual increase in sludge layer of up to 15-20 cm is possible.

Typical characterisitics

Typically sludge drying reed beds are designed for sludge loading in intervals of 2-3 weeks, the sludge volume to be loaded depending on the TSS concentration. The design storage period of the sludge is between 8 and 12 years, followed by a secondary treatment (composting either inside the reed be or externally). This process achieves a final product with a dry solid content of more than 40 %, which is suitable for reuse.

Key facts:

- The first sludge drying reed bed in Montenegro is designed for 2‘600 p.e
- Design criteria of sludge drying reed bed in similar climatic regions have been used for sizing the beds
- Required surface area of the beds is 880 m², i.e. about 0.35 m²/p.e.

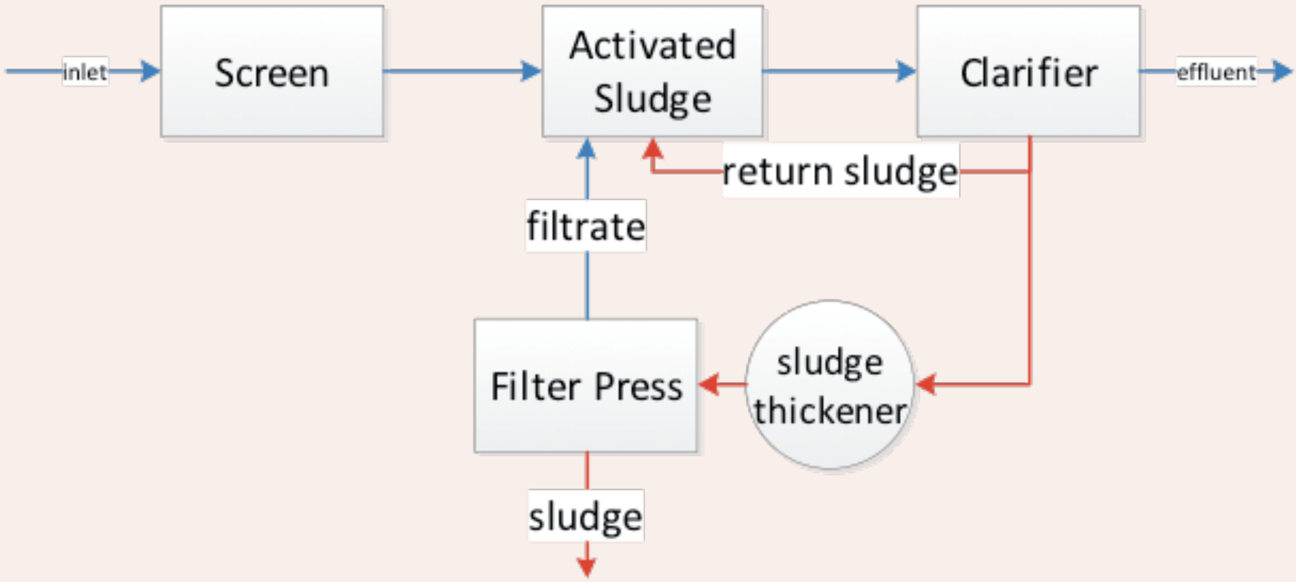

Figure 1: Current flow scheme

Process

Sludge drying reed beds typically use the combined effects of reed, microorganisms in the root zone, sewage sludge and the filter material at the bottom of the bed. Generally, the same processes as in constructed wetlands for wastewater treatment take place:

Dewatering

- Transpiration
- Evaporation
- (Infiltration)

Oxygen Supply

- Roots
- Pores
- Cracks

Stabilisation and isolation during cold times

- vegetation dieback

Microorganisms

- aerobic decomposition

Objectives

Objectives of the process described above are the reduction of the sludge water content below 50%, going hand in hand with a reduction of volume by 90%. This volume reduction has a direct impact on cost for energy, operation and maintenance and transport of the sludge. A final secondary composting phase of 1 year shall assure sanitation (disinfection). In addition to these objectives a major benefit of sludge treatment in sludge drying reed beds is the production of valuable compost (Kołecka and Obarska-Pempkowiak, 2013).

Current situation

Process

The current flow scheme is shown in Figure 1 below. Although designed for 5‘250 PE using two parallel treatment lines, currently only a capacity of 50 % is installed. Sludge is withdrawn from the return sludge lines manually depending on the MLSS concentration in the activated sludge reactor and pumped to a sludge thickener. From the sludge thickener the sludge should be pumped to a filter press for dewatering, however due to a too small intake line from the sludge thickener to the pump (DN50) the filter press cannot be operated.

Design

General

Sludge drying reed beds may be realized as concrete basins or basins sealed with synthetic sheets (rubber, PE, PP). Commonly the depth is between 1.2 and 1.7 m.

Leachate will be recirculated to the wastewater treatment plant (inlet activated sludge tank).

As a rough estimate the required specific surface area can be assumed with 0.25-0.50 m²/PE (Kainz, 2006). This assumption results in a total required (net) area of 1‘300 to 2‘600 m² for 5.250 PE.

Climate

Climatic data – precipitation and temperature – are shown in Figure 2. The data was used to select design assumptions from countries with comparable climatic conditions.

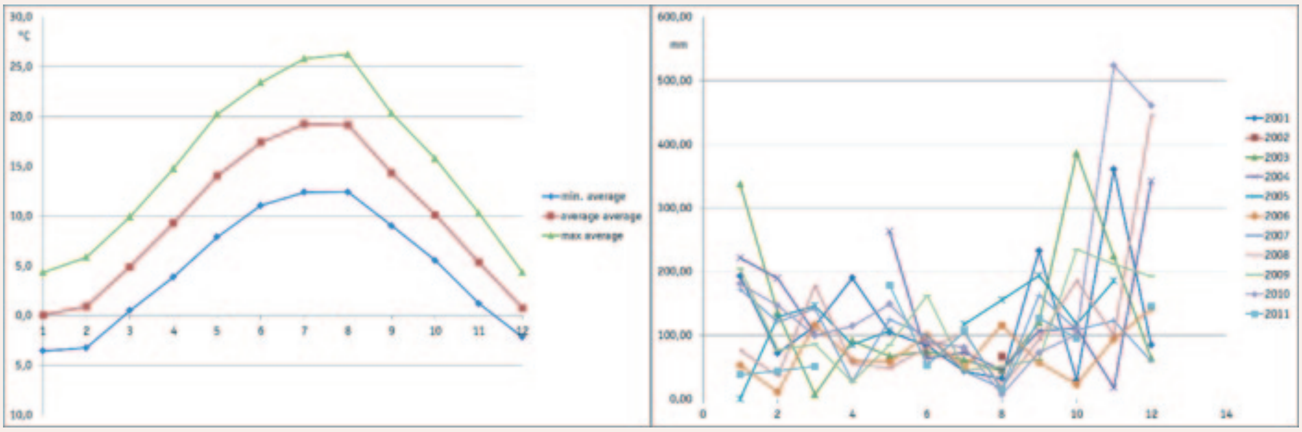

Figure 2: Temperature and precipitation

Design Assumptions

Currently the wastewater treatment plant has a nominal capacity of 50 % of the design capacity, i.e. app. 2‘600 PE. For this reason the sludge treatment was designed for a capacity of 2‘600 PE.

The design assumptions are summarized in Table 1. Although the treatment plant is in operation no monitoring data on wastewater quality at inlet or outlet, respectively operational parameters (TSS, vTSS, etc.) are available and the design assumptions had to be based on literature values, resp. experience.

Considering the solids retention time at design capacity and an assumed TSS inlet concentration the surplus sludge generation was assumed to 80 g/PE/d with a volatile share of 2/3 and a water content of 99 %. Relative sludge generation by precipitation of phosphates was assumed to be 15 g/PE/d with a small share of 3g vTSS / PE/d.

The existing thickener with slow turning mixer and a theoretical retention time of app. 30 days was assumed to generate a reduction in water content to 95 %, equivalent to a volume reduction of 80 %.

Load	2600	PE
relative sludge generation activated sludge	80 g/PE/d	TSS
	55 g/PE/d	vTSS
	99 %	water content
Relative sludge generation P-precipitation	15 g/PE/d	TSS
	3 g/PE/d	vTSS
	99 %	water content

These design assumptions result in a design load of 247 kg sludge per day and a volume of 4.9 m³/d after the sludge thickener.

Sludge drying reed bed

The design of sludge drying reed beds is based on empiric design recommendations which have been proven to be successful in the past. Design assumptions are frequently based on maximum permissible loading rates – Troesch et al. (2009) gives a range from 40 – 250 kg TSS/m²/a – depending on the origin of the sludge, the degree of stabilisation as well as the climatic conditions.

Based on relative sludge generation assumptions this approach is equivalent to defining a minimum required area of sludge drying bed per PE (e.g. 0.25-0.5 m²/PE according to Reinhofer, 2000).

For this project, the design has been based on a maximum permissible increase in sludge layer per year. This approach is consistent with the basic requirement of providing sufficient oxygen for rapid composting in the top layers of the sludge drying bed. The assumed maximum permissible annual increase in sludge layer of 0.20 m is equivalent to a loading rate of 80 kg/PE/d, respectively 0.43 m²/PE and as such well within literature recommendations. This results in a total required area of 880 m², which is divided onto two sludge beds for operational reasons. As shown in Figure 4 thickened sludge will be withdrawn from the existing sludge thickener and discharged via a sludge pumping station to one of the sludge beds. The discharge will be done alternately, allowing a sufficiently long resting period for each bed.

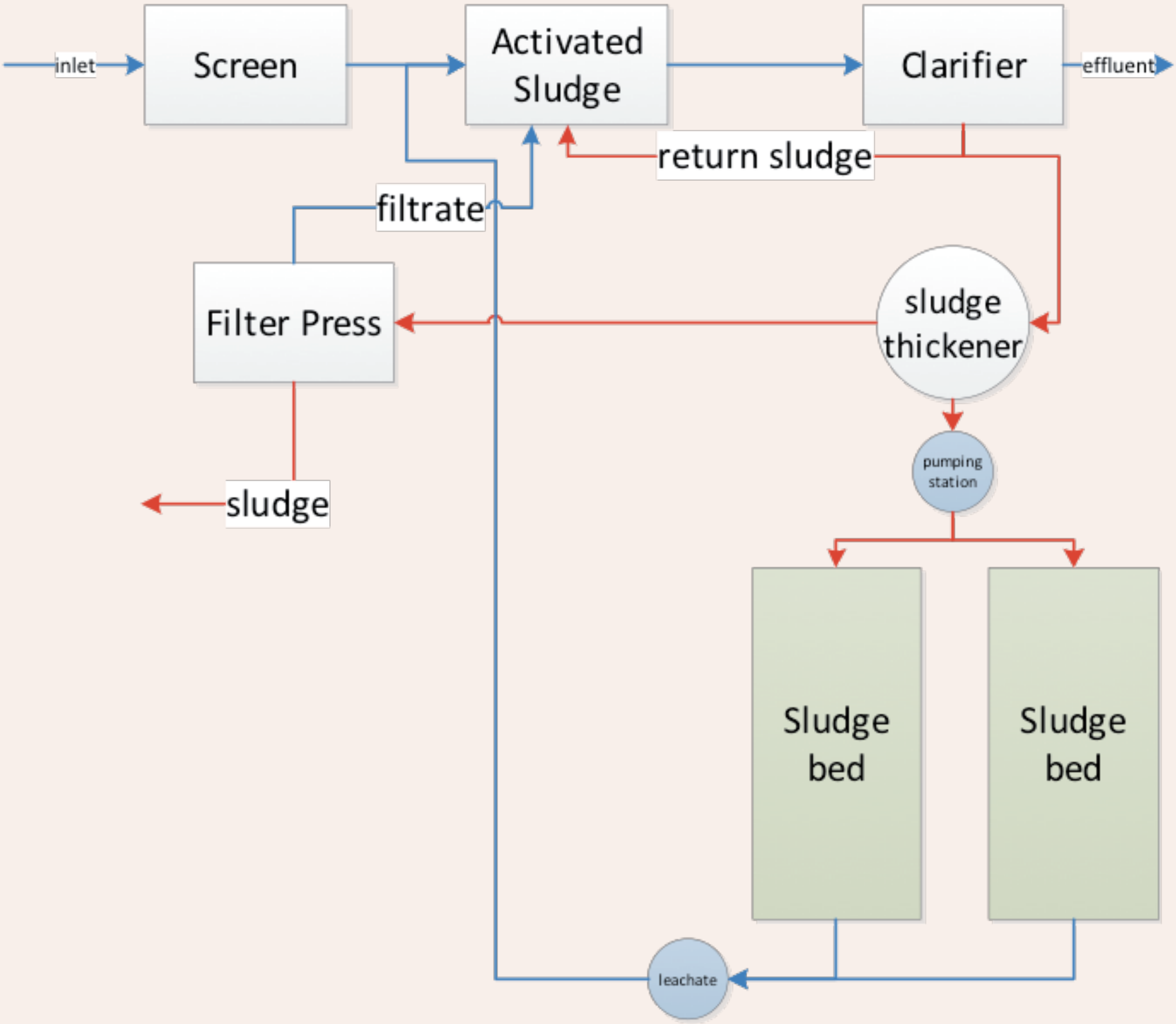

Figure 3: Proposed new flow scheme

The cross section of the sludge drying reed beds is shown in Figure 4. Leachate is collected at the bottom of the sludge drying reed beds and returned to the wastewater treatment plant.

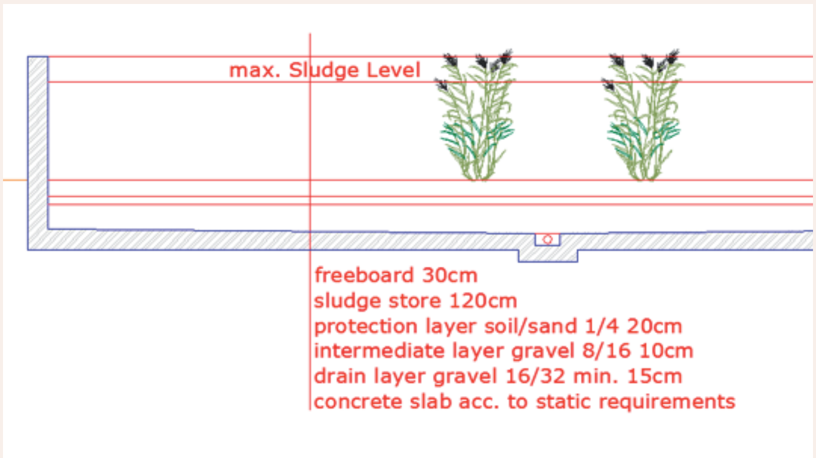

Figure 4: Sludge drying reed bed – cross section

Operational Issues

The sludge drying reed beds will be used for a total design period of 8-12 years. At an interval of 2-3 weeks (depending on the season and the actual progress of dewatering) sludge will be pumped to one of the sludge drying reed beds, the quantity designed to achieve a maximum increase in sludge level of 20 cm per year.

After reaching the maximum design sludge level a resting period of 12 months starts, during which no sludge will be added and the composting process completed. After this period, the sludge will be removed from the sludge drying reed bed and the process starts afresh.

Depending on the actual quality and the intended utilization, an additional storage period of the sludge may be required after removing it from the sludge drying reed bed.

Construction & performance monitoring

Construction of the sludge drying reed beds will start in 2014. Being the first sludge drying reed bed of this kind in Montenegro the Ministry will design and implement a performance monitoring system.

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