

Ulf Meyer-Scharenberg, Marcus Pöppke

Large-scale Solar Sludge Drying in Managua/Nicaragua

Within the framework of a programme aimed at reducing the biological contamination of Lake Managua, a central wastewater treatment plant for the city of Managua (1.1 million p. e.) was constructed and commissioned at the end of 2009. Annual sludge production amounts to 26,000 m³ and sludge disposal and/or reuse thus present a major challenge. Based on the results of extensive studies, the combination of solar sludge drying and subsequent reuse in agriculture was considered the most appropriate solution. This approach was honoured with a 'Distinction' awarded by the Global Water Intelligence in 2010.

1. Introduction

Throughout the past decades, Lake Managua or Lago Xolotlán with its total surface of about 1,000 km² has served as main recipient for all sorts of wastewater, domestic and industrial from the city of Managua being the principal source of pollution. Considering the fast growing population of the capital (already more than 1 million inhabitants) and the constantly decreasing water quality in the lake, a comprehensive environmental rehabilitation and protection programme was launched in the nineties. A key element of this programme was the construction of a central wastewater treatment plant on the shore of the lake that should reduce biological contamination (Tab. 1). The programme is implemented by the National Water and Sewerage Company of Nicaragua (ENACAL) and financed through German KfW Development Bank.

On account of the plant size, the appropriate treatment and disposal of sludge presented one of the main challenges. Total annual sludge production was estimated at 26,000 m³, i.e. more than 80 m³/working day.

2. Selection of an appropriate sludge concept

Originally, the sludge was supposed to be disposed on a municipal landfill site after digestion and mechanical dehydration. Apart from the high costs and the risk of future legal restrictions, the disposal of sludge on public landfills presents further unpredictable problems and risks, which seem negligible at first sight, but should nevertheless be taken into consideration. In Managua for example, entire families earn their living through recycling of material found on the landfills. If the waste is covered with sludge, these people are deprived of this possibility. During the first phase of plant operation with the sludge drying plant not yet in operation, the sludge had to be disposed on the landfills, where truck drivers were physically attacked by individuals defending their claims.

During project implementation, the Consultant proposed to assess alternative sludge treatment options. Based on the comparison of 12 different technologies,

solar drying was selected as the most feasible one, mainly because of flexible sludge reuse, favourable energy balance and low operation costs.

The analysis of sludge quality and the potential demand for dried sludge as fertilizer in the local agriculture were other decisive factors for the selection of an adequate concept. At that time, it could already be forecast that sludge would be rich in nitrates and phosphor, have low or no heavy metal concentrations and be at least of Class B according to EPA classification (Pathogen Requirements and Requirements for Domestic Septage Applied to Agricultural Land, a Forest, or a Reclamation Site).

Workshops revealed that sludge reuse enjoys wide acceptance among the farmers and confirmed that sufficient demand was to be expected. Another favourable argument to reuse the sludge in agriculture was the reduction of CO₂ emissions in the range up to 10.000 t/a due to the replacement of industrial fertilizers that are widely used in Nicaragua.

Tab. 1 | Project key data

Capacity of WWTP	1.1 million p.e.
Maximum flow to the treatment plant	297,000 m ³ /d
BOD ₅	50,000 kg/d
Design quality of treated effluent	Total suspended solids: 80 mg/l
	BOD ₅ : 30/90 mg/l (filtered/homogenized sample)
	COD: 180 mg/l

Tab. 2 | Main design parameters and prerequisites to be met in the drying process

Annual sludge production	26,000 m ³
Average dry solids (DS) content after mechanical dehydration	28 %
Annual DS production	7,250 t
Required final DS content	> 60 %
Safe and easy operation	
Option for composting required, implying higher layers of sludge	



Figure 1: Panoramic view of the entire solar sludge drying plant



Figure 2: WendeWolf® machine completely installed in a greenhouse

Tab. 3 | Characteristics of the solar drying plant

Number of halls	6 (5 totally equipped)
Width (effective drying) of halls	12 m (11.3)
Length (effective drying) of halls	122 m (116)
Area (effective drying) of one hall	1,460 m ² (1,310)
Ventilators to improve air circulation	14 per hall

3. Technology and design of the solar sludge drying plant

Solar radiation, temperature and humidity as well as the annual fluctuations of these parameters constitute the main design factors for the dimensioning of the system. In Managua, solar radiation and temperature are relatively constant throughout the year with average values of 20 MJ/m²/day and 28 °C. The relative humidity varies between 60 – 80 %. To ensure a safe dimensioning of the plant, the system layout is based on the values of the rainy season. The main parameters and prerequisites to be met in the drying process are presented in **Tab. 2**.

In view of these general conditions and requirements, the WendeWolf® technology was selected for implementation. This system consists of a turning and conveying machine mounted on two parallel concrete walls. The whole system is placed on a horizontal surface, which is covered by greenhouses. The dehydrated sludge is dumped at one end of the hall and the machine is conveying the material to the other end within 21 days, producing a dry granulate with an average grain size of 10 mm. The granulate is easy to handle for storage and transportation from site.

Compared to industrial dryers, the system's energy demand per ton of evaporated water is very low. Another major advantage is its easy operation and maintenance.

The main characteristics of the drying plant are summarized in **Tab. 3**. The entire

plant occupies an area of 8,850 m². Furthermore a storage area covering 1,360 m² is necessary because the dried sludge cannot be spread during the rainy season. These dimensions make it the largest solar sludge drying facility in the Americas. **Fig. 1 and 2** show a panoramic view of the plant and details of the WendeWolf® machine.

4. Evaluation and outlook

The initial operation phase has proved that the selected system is working properly with low operation costs for energy and staff.

It can be confirmed that the dried sludge is odourless and has a proper granular structure. Based on the first analyses it can be expected that the dried sludge will meet the requirements of Class A sludge (EPA), allowing thus for unrestricted reuse in agriculture.

Within a 3 weeks cycle, the DS content increased from 28 % to 70 % and during the rainy season a mass reduction of 4,300 kg/m²/year was measured, which exceeded all expectations. During a 30 days test, a DS content of 87 % was obtained. Thanks to these results, a continuous operation of the ventilators is not necessary. The energy demand per ton of evaporated water amounts to 20 kWh, which is far below the energy consumption of industrial dryers (800 – 1,000 kWh).

The construction costs for an installation of this size (excl. land acquisition) amount

to about 5 million EUR. That means an investment cost of about 690 EUR/ton of annual DS production. Operation and maintenance costs sum up to about 40 (75) EUR/ton of DS excl. (incl.) depreciation, amounting thus to a cost of less than 0.01 EUR/m³ of wastewater, incl. depreciation, which would have a negligible impact on the wastewater tariff.

The experience gained in Managua shows that solar sludge drying is an excellent option for sludge treatment provided that sufficient space is available for greenhouses and storage areas. Whereas in favourable climatic environments such as Nicaragua, space requirements are relatively small, they increase considerably in colder regions.

Sludge drying usually is a highly energy-intensive process, but as the selected system is a low-cost and low-energy technology; it constitutes an important contribution to environmental protection in the wastewater sector. This fact has been honoured by a 'Distinction' awarded to the project by the 'Global Water Intelligence' at the occasion of the Global Water Awards 2010.

Authors

Dipl.-Ing. Ulf Meyer-Scharenberg
Dipl.-Ing. Marcus Pöppke

Fichtner Water & Transportation GmbH,
Linnéstraße 5, D-79110 Freiburg
E-mail: ulf.meyer-scharenberg@fwt.fichtner.de