ANNEX 9: DIRECT BENEFITS ASPECTS AND INDICATORS

1. *Avoided capital expenditures*

Monetised benefits allow us to quantify direct benefit values. They do provide significant insights and indications on the relevant value. The avoided expenditures by implementing mechanical dewatering instead of RBs are shown in the table below.

Table 1: Avoided expenditures -the direct benefits of using mechanical dewatering in Mojkovac

Project investment cost	**Reed beds**	**Mechanical dewatering**	**Avoided expenditures**
*TOTAL INVESTMENT COSTS (EUR):	193.000	134.475	58.525
CAPEX (EUR/P.E.):	**77**	**54**	**23**

* Including project documentation, construction, operation staff training and dissemination.

The above table represents the direct benefit of using mechanical dewatering instead of RBs in WWTP Mojkovac. The total investment cost per people equivalent (PE) for the implementation of mechanical dewatering is for 30 % lower in comparison with the implementation of RBs.

Figure 1 shows investment options for sludge treatment in Mojkovac. Taking decisions can be tough. Taking complex decisions is even tougher. Most wastewater treatment decisions are probably at the stricter end of the complex. They can affect the performance of treatment, impact inhabitants, environment, finances, and their flows. In this setting, rigor in decision making is critical - so which sludge treatment technology is the most appropriate for specific agglomeration. Looking only from the aspect of initial investment costs can make decisions simple and easy, but many other elements need to be factored into the decision process.

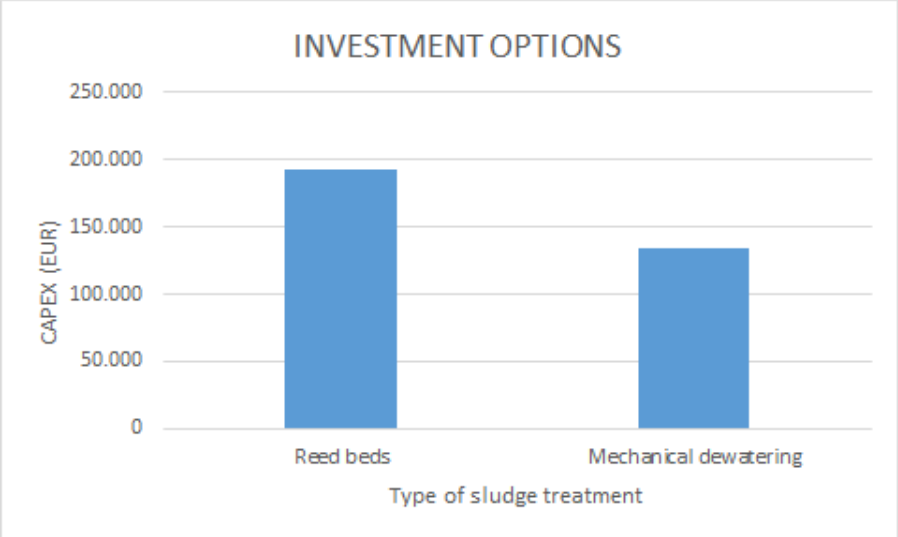

Figure 1: Investment options for sludge treatment in Mojkovac

2. *O&M cost savings*

Comparing reed beds to mechanical dewatering, reed beds do not require sludge removal at every dewatering cycle.

From Table 2 wo types of savings using RBs in WWTP process in Mojkovac can be estimated. For the first type, the O&M costs are calculated, taking into account the incineration of sludge derived from the RBs. The annual savings with the use of RBs instead of mechanical dewatering are 13.271 EUR Y^1. In the second scenario considered, where the formed sludge is used for biosolids reuse, savings of EUR 15.600 EUR Y^1 are generated.

Table 2: Annual cost savings of using reeds instead mechanical dewatering

O&M costs	Reed beds	Mechanical dewatering	Annual cost saving
TOTAL O&M costs without final disposal (EUR/year)	**3.987**	**8.826**	**3.932**
TOTAL O&M costs with incineration (EUR/year):	**9.654**	**27.726**	**18.072**
TOTAL O&M costs with biosolids reuse (EUR/year)	**5.404**		**22.322**

The option with reed beds + biosolids reuse is about 1,6 times more cost-effective for the people of Mojkovac than mechanical dewatering + incineration scenario.

3. Efficiency of WWTP with RBs in operation

Using RBs for wastewater treatment for a sustainable treatment process can ensure the economic and energy efficiency during the annual operations. The following figures present the trends of the main parameters for three years (2015-2017) in WWTP Dellach with implemented RBs treatment of sludge produced.

Based on these parameters, the efficiency in WWTP using RBs in Dellach (Austria) and WWTP in Sillistra (Bulgaria) using mechanical dewatering of sludge was compared.

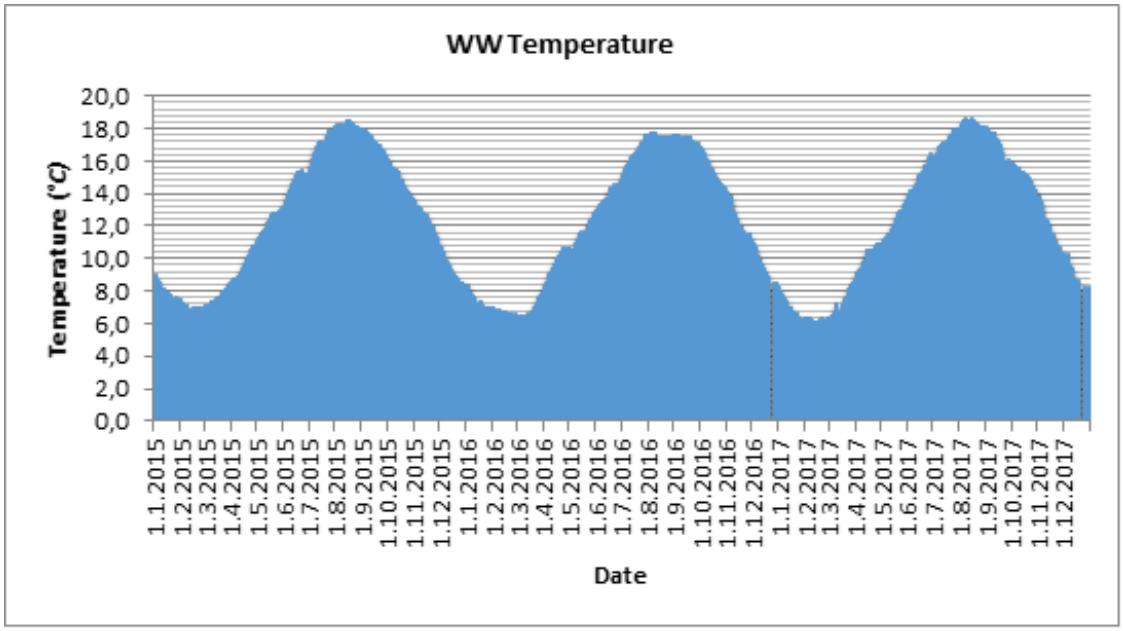

Figure 2: Water temperature

It is essential to analyse main parameters and ratios (C:N; N:P ;C:P) when using activated sludge as the conventional method for wastewater treatment. Rates between the three primary parameters – C, N and P are presented in the following figures: Figure 3 - C:N ratio, Figure 4 – N:P ratio. The nitrogen and phosphorus ration show have values below the normal levels. In the table below, one can observe that despite the unusual parameters of the leading pollution indicators (C:N, C:P,N:P), WWTP with RBs has better efficiency than WWTP than with mechanical dewatering systems.

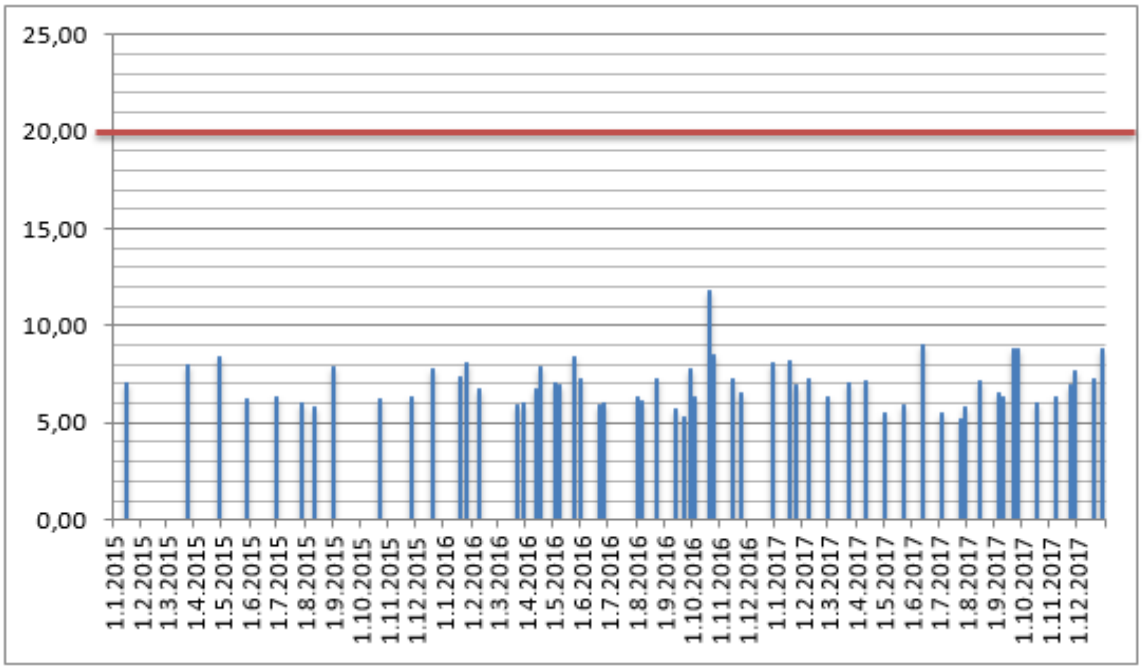

Figure 3: C:N ratio

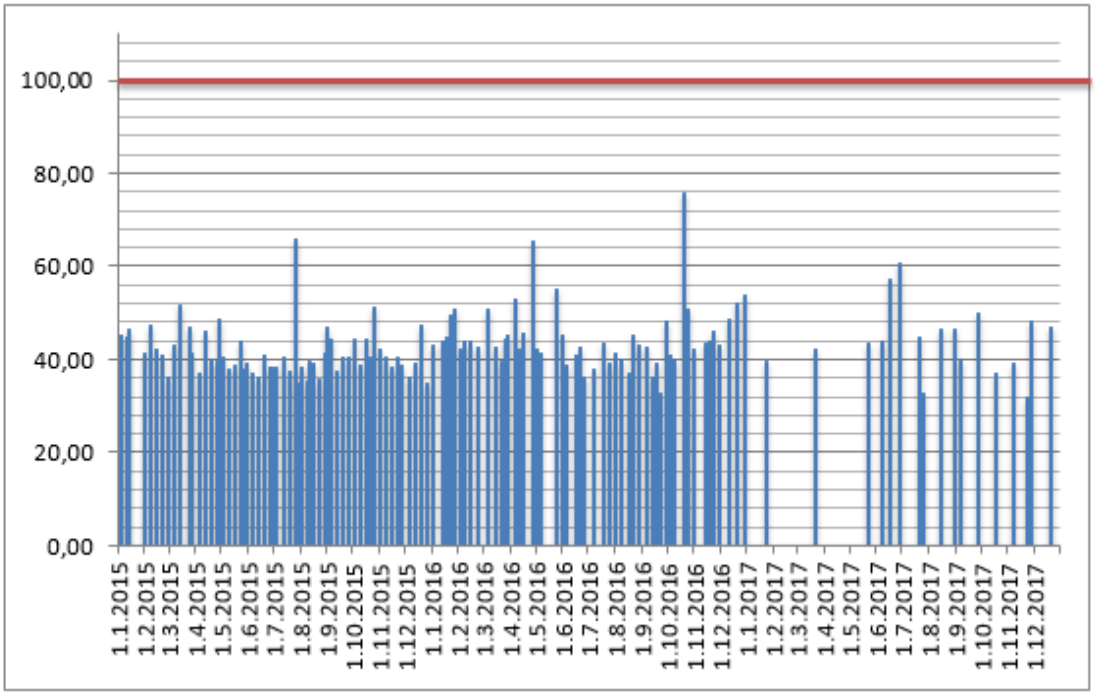

Figure 4: C:P ratio

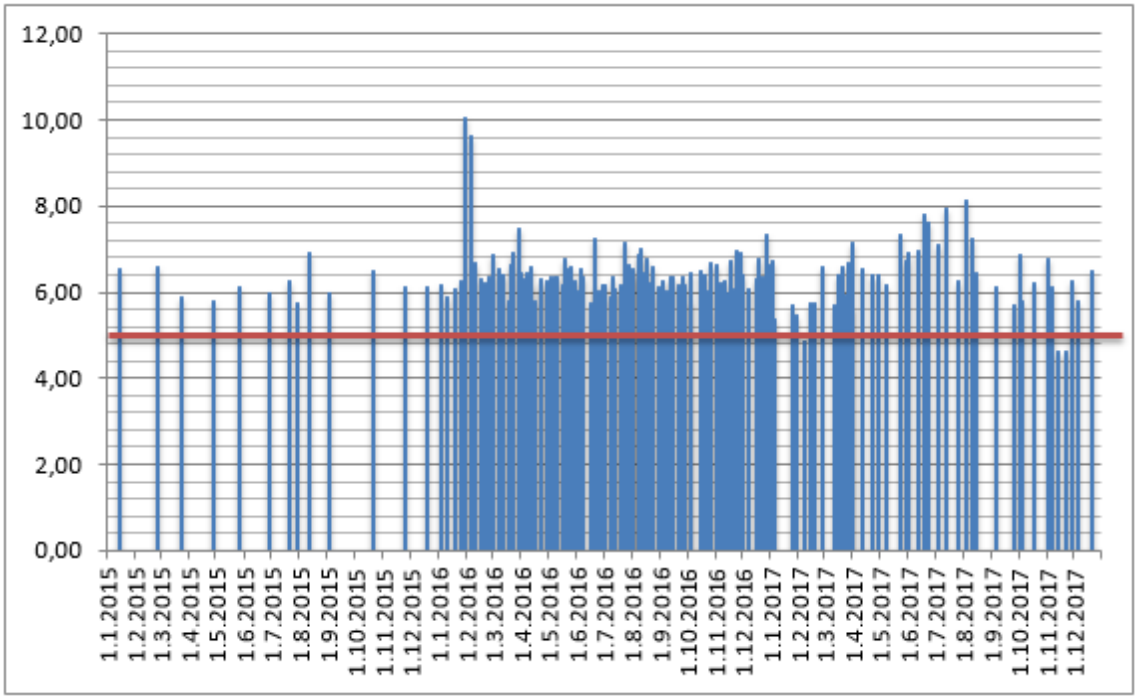

Figure 5: N:P ratio

Table 3 compares the collected data for two types of WWTP (with RBs and with mechanical dewatering), giving an overview of the total efficiency during the operation process expressed through the consumed energy for the treatment of the main parameters: BOD, COD, Total N and Total P.

Table 3: Energy efficiency indicators for WWTP with RBs in a three years period

WWTP	Year	Type	Electricity consumption				
			kWh/m³	kWh/KgBOD/d	kWh/KgCOD/d	kWh/KgN/d	kWh/KgP/d
WWTP with RBs[1]	2015-2017	I	0,148	0,248	0,157	1,822	11.452
WWTP with MD[2]	2014-2015	I I	0,152	1.071	0.291	6.024	32.427

Types:
I –treatment of excess sludge with reed beds
I I –treatment of excess sludge with mechanical dewatering

One can conclude that reed beds for dewatering of excess sludge increase WWTP efficiency, compared to mechanical sludge dewatering.

[1] WWTP Dellach, Austria. Designed for 7.800 P.E.
[2] WWTP Silistra, Bulgaria. Designed for 45.000 P.E. At the moment works for about 8.000 – 15.000 PE