REPUBLIC OF MOLDOVA

APA CANAL CHISINAU

CHISINAU WATER SUPPLY & SEWAGE TREATMENT - FEASIBILITY STUDY

Contract No: C21156/ECWC-2010-01-01



Wastewater Treatment - FINAL

August 2012

seureca **A Subsidiary of** VEOLIA ENVIRONNEMENT

In association with **and** Business Consulting Institute

European Bank for Reconstruction and Development **and EU Neighbourhood Investment Facility**

LIST OF ABBREVIATIONS AND ACRONYMS

ACC	Apa Canal Chisinau
ANRE	National Agency for Energy Regulation
BAT	Best Available Technology
BCI	Business Consulting Institute
BOD	Biochemical Oxygen Demand (5 days unless otherwise stated)
CAPEX	Capital Expenses
CAS	Conventional Activated Sludge
CHP	Combined Heat and Power
COD	Chemical Oxygen Demand
DO	Dissolved Oxygen
EU	European Union
GHG	Greenhouse Gases
IW	Intrusive Water
MLSS	Mixed Liquor Suspended Solids
NH4	Ammonium
KN	Kjeldahl Nitrogen
NO2	Nitrite
NO3	Nitrate
OPEX	Operation Expenses
ORP	Oxidation Reduction Potential
PE	People Equivalent
RES	Renewable Energy Source
TDS	Total Dissolved Solids
TN	Total Nitrogen
ToR	Terms of Reference
TP	Total Phosphorus
TS	Total Solids
TSS	Total Suspended Solids
UN	United Nations
VS	Volatile Solids
VSS	Volatile Suspended Solids
WW	Wastewater
WWTP	Wastewater Treatment Plant

Special note

All concentrations are expressed in mg/L unless otherwise stated. Besides, concentrations of nitrogen compounds and phosphorus compounds are expressed in mgN/L and mgP/L respectively.

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1. TERMS OF REFERENCE

Phase B.5 Wastewater Treatment including Sludge Disposal

Present and summarise the investment measures proposed for improving Wastewater Treatment including Sludge Disposal	B.5.	SEURECA	Treatment Specialist

PhaseC.5 Wastewater Treatment including Sludge Disposal

Preliminary Design for the PIP programme elements	C.5.		
Hydraulic calculations		SEURECA	Treatment Specialist
Report		SEURECA	Treatment Specialist
Preliminary Engineering Design documentation (BoQ & Drawings & Preliminary cost estimates)		IA	Water Eng. & CAD operator

2. DESIGN CRITERIA

2.1. INTRODUCTION

A summary of the main facilities of the existing WWTP is presented below. For a more detailed description, the reader should refer to the WWTP assessment which is part 3.3.2 and 5.6 of the inception report of this study.

2.2. EXISTING FACILITIES

The existing WWTP dates back from the 70s and was built in several stages although it is very likely that it has never worked at full capacity. Only about 50 % of the works are currently being used (Figure 1). The wastewater treatment process implemented at Chisinau WWTP is a medium load contact-stabilization activated sludge featuring the following steps:

- Mixing chambers
- Fine screening
- Intermediate pumping
- Sand removal
- Primary settling
- Biological treatment (medium load contact-stabilization activated sludge)
- Secondary clarification
- Chlorination (not in use any longer)
- Discharge into the Bic River

The sludge treatment line initially included static thickeners and digesters and drying beds before final disposal. However the digesters have never been commissioned due to construction defaults and therefore this treatment line has never been in operation. The mixture of primary and biological sludge has been directly disposed onto drying beds instead, which caused serious odour problems. Geotubes have recently been installed to reduce these problems. The dehydrated sludge is currently disposed of in a dumping site nearby the plant.

The current process flow diagram is presented in Figure 2. It clearly shows the specificity of Chisinau WWTP in terms of excess sludge management. Because it is not possible to thicken the excess biological sludge, the latter is transferred to the inlet chamber where it is mixed with raw wastewater. The biological sludge settles down in the primary settling tanks from where both sludge types are pumped together to the Geotubes. The current sludge management is dictated by practical reasons but is not recommended.

Figure 1: Tanks in operation at Chisinau WWTP

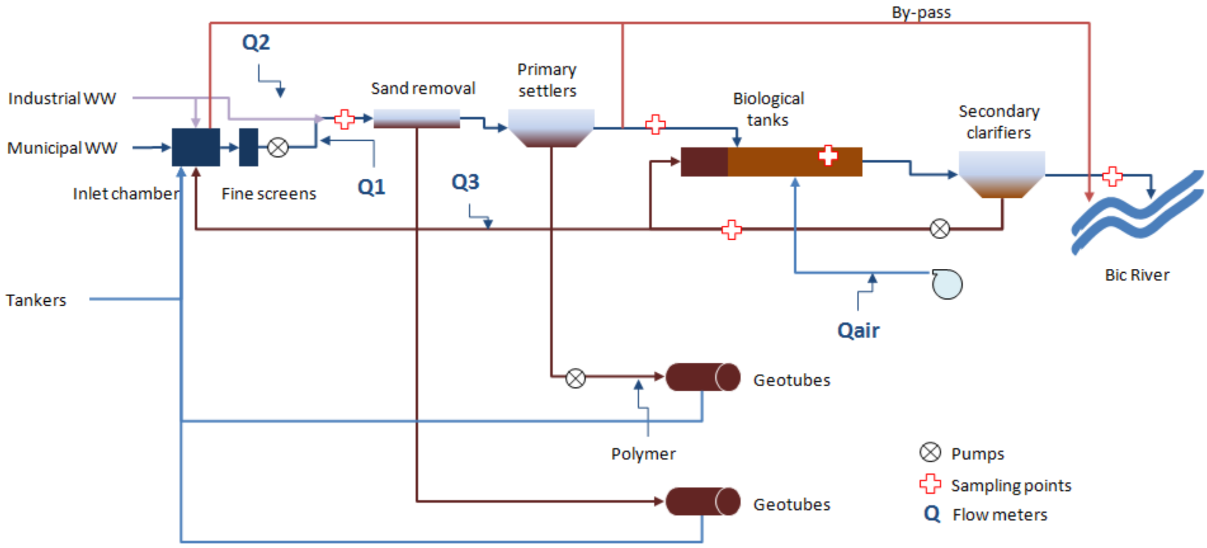


Figure 2: Process flow diagram of Chisinau WWTP

2.3. WASTE WATER CHARACTERISTICS

2.3.1. CURRENT SITUATION

2.3.1.1. Summary of the existing data

Routine monitoring by ACC

The sampling point used by ACC to monitor the quality of the incoming wastewater is located just upstream the sand removal tanks (Figure 2). The recorded data (Table 1) then correspond to the stream that enters the treatment process but does not represent the quality of the raw wastewater due to the mixing with other streams as previously mentioned which especially increase the content of organic material and total suspended solids through the recirculation of settled sludge from the secondary clarifiers.

Table 1 Composition of the wastewater upstream the sand removal tanks (average values for the period running from 01/01/2010 until 30/09/2010)

		Inlet
COD	mg/L	739
BOD5	mg/L	338
TSS	mg/L	542
NK	mg/L	56
NH4	mg/L	46
P-PO4	mg/L	9
Temperature	°C	18.5
pH	-	7.3

Exceptional monitoring by ACC in 2005

A specific analytical campaign was performed in 2005 by ACC. From September 26th until September 30th the wastewater at the entrance of the inlet chamber - assimilated to “municipal” wastewater – was sampled and analyzed every 3 h. The resulting average values (not flow-weighted) are provided in Table 2 while the evolution of the concentrations with time is presented in Figure 3. The daily trends do not appear very clearly although the usual pollution trend can be recognized when looking at COD only, a first increase in late morning followed by a second one in late afternoon and then a decrease during the night.

Table 2 Average composition of the raw wastewater entering the inlet chamber (“municipal” flow) from 26/09/2005 until 30/09/2005 (the values are not flow-weighted).

		Inlet
COD	mg/L	678
BOD5	mg/L	264
TSS	mg/L	525
NK	mg/L	NA
NH4	mg/L	40
PO4	mg/L	7
Temperature	°C	NA
pH	-	NA

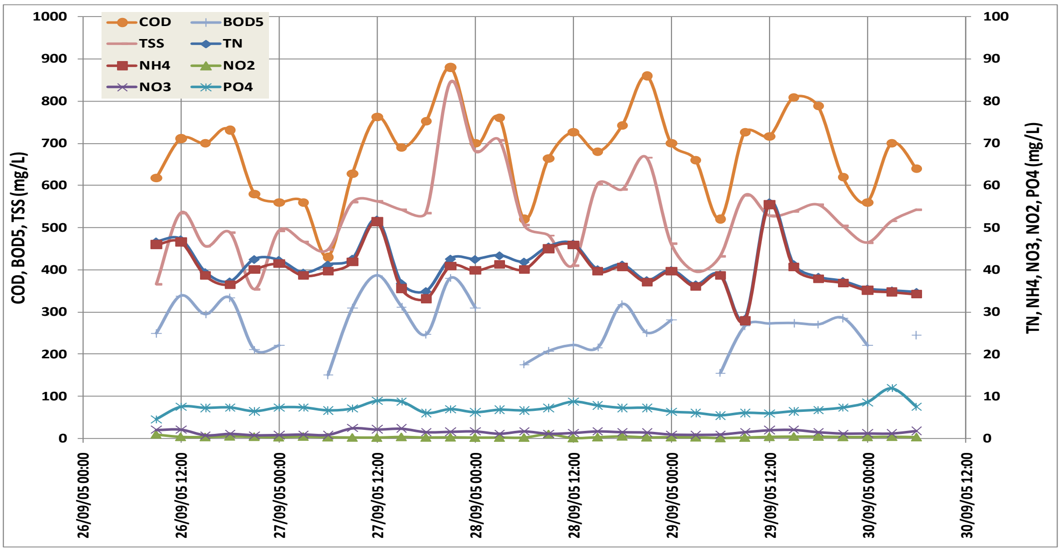


Figure 3: Evolution of various parameters in the raw "municipal" wastewater entering the inlet chamber from 26/09/2005 until 30/09/2005.

Exceptional monitoring by ACC in 2009

From June 1st 2009 until June 24th 2009 the sludge recirculation from the secondary clarifiers to the second inlet chamber was stopped. The concentrations found at the sampling point are therefore thought to be more representative of the raw wastewater to be treated during this period. The average concentrations obtained during this period are presented in Table 3.

Table 3 Composition of the wastewater upstream the sand removal tanks without sludge recirculation (average values for the period running from 01/06/2009 until 24/06/2010)

		Inlet
COD	mg/L	500
BOD5	mg/L	208
TSS	mg/L	278
NK	mg/L	NA
NH4	mg/L	NA
TP	mg/L	NA
Temperature	°C	19.0
pH	-	NA

Preliminary specific campaign

A specific measurement campaign was implemented on January 20th 2011 in order to get a better picture of the daily evolution of the concentrations of the raw wastewater to be treated at Chisinau WWTP.

The concentrations of relevant quality parameters have been analyzed every 2 hours at the entrance of the second inlet chamber - where the water is representative of the "municipal" stream before it is mixed with other streams - and at the outlet of the pipe discharging industrial effluents. The results are presented in

Figure 4 and in Table 4. The main conclusions drawn from this study - which is thought to be representative of a usual situation since the flow rate was approximately 156,000 m^3/d on that particular day - are as follows.

- As expected, the "industrial" wastewater is by far more concentrated than the "municipal" wastewater for all parameters tested, except pH and Total phosphorus, with very high peaks (especially for COD and BOD5 and TSS).
- As expected, the variations of the concentrations are much higher for the "industrial" wastewater than for the "municipal" wastewater.
- The evolution of the concentrations in the "municipal" wastewater highlights one significant peak in early morning (around 7 AM).
- The contribution of the "industrial" load to the total load is below 3 % for all parameters except for BOD5 (5 %).

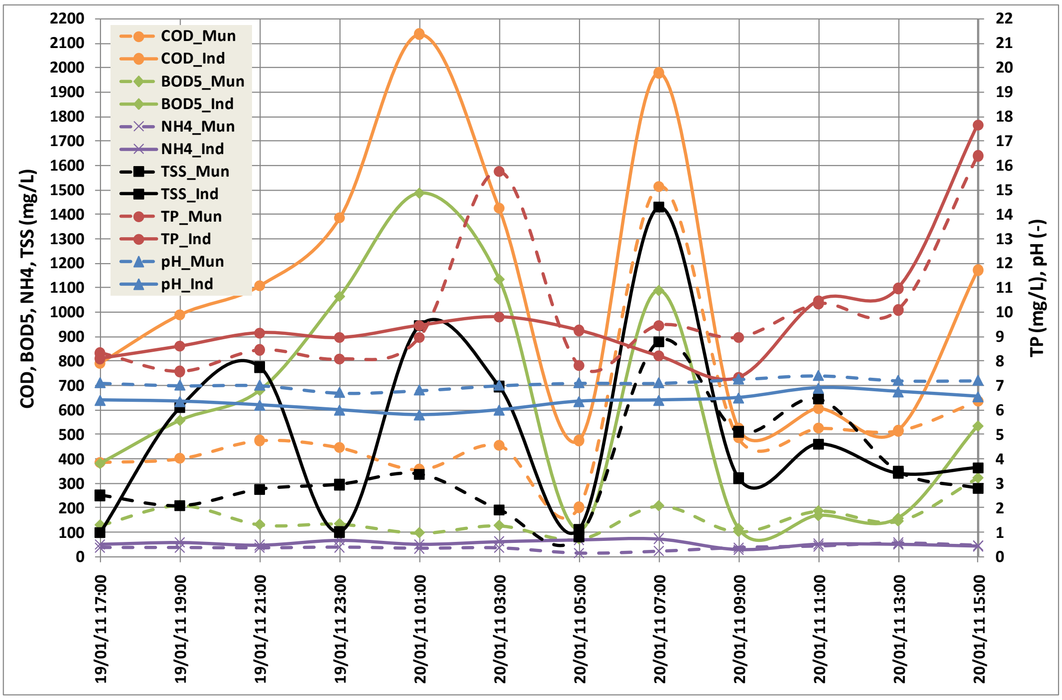


Figure 4 24h evolution of the concentrations of the main water quality parameters in the "municipal" stream (dotted line) and in the "industrial" stream (solid line).

Table 4 Analytical results of the preliminary measurement campaign (in italic) and associated load calculations and composite sample characteristics.

	pH	SS	COD	BOD5	NH4	Ptotal	Flow rate	SS	COD	BOD5	NH4	Ptotal
	-	mg/L	mg/L	mg/L	mg/L	mg/L	m3/h	kg/h	kg/h	kg/h	kg/h	kg/h
"municipal" wastewater												
19/01/2011 17:00	7.1	250	386	129	37.5	8.33	6733	1683	2599	869	253	56
19/01/2011 19:00	7	207	401	210	37.5	7.57	6186	1281	2481	1299	232	47
19/01/2011 21:00	7	275	475	131	36	8.45	6026	1657	2862	789	217	51
19/01/2011 23:00	6.7	295	446	134	39	8.07	6268	1849	2796	840	245	51
20/01/2011 01:00	6.8	337	356	97	34.5	8.96	6358	2143	2263	617	219	57
20/01/2011 03:00	7	191	455	127	36	15.8	6007	1147	2733	763	216	95
20/01/2011 05:00	7.1	81	202	71	15	7.82	6031	489	1218	428	91	47
20/01/2011 07:00	7.1	880	1515	208	22.5	9.46	6790	5975	10287	1412	153	64
20/01/2011 09:00	7.3	510	485	102	37.5	8.96	6205	3165	3009	633	233	56
20/01/2011 11:00	7.4	645	525	187	43.5	10.3	6761	4361	3550	1264	294	70
20/01/2011 13:00	7.2	349	515	145	55.5	10.1	7048	2460	3630	1022	391	71
20/01/2011 15:00	7.2	279	636	323	46.5	16.4	6827	1905	4342	2205	318	112
Average	**7.1**	**358**	**533**	**155**	**37**	**10**	**6437**	**2343**	**3481**	**1012**	**238**	**65**
Load (kg/d)								56227	83540	24283	5723	1552
"industrial" wastewater												
19/01/2011 17:00	6.4	97	792	381	50.7	8.1	17	2	13	6	1	0
19/01/2011 19:00	6.4	610	990	557	58.2	8.6	41	25	41	23	2	0
19/01/2011 21:00	6.2	775	1109	680	46.9	9.15	180	140	200	122	8	2
19/01/2011 23:00	6	100	1386	1064	67.5	8.95	0	0	0	0	0	0
20/01/2011 01:00	5.8	944	2138	1486	50.7	9.45	61	58	130	91	3	1
20/01/2011 03:00	6	696	1426	1134	61.9	9.8	86	60	123	98	5	1
20/01/2011 05:00	6.4	110	475	108	69.4	9.25	30	3	14	3	2	0
20/01/2011 07:00	6.4	1429	1980	1088	73.2	8.2	244	349	483	265	18	2
20/01/2011 09:00	6.5	321	525	115	28.1	7.32	0	0	0	0	0	0
20/01/2011 11:00	6.9	460	606	168	51	10.5	91	42	55	15	5	1
20/01/2011 13:00	6.8	340	515	157	50.7	11	162	55	83	25	8	2
20/01/2011 15:00	6.6	363	1172	534	43.2	17.7	0	0	0	0	0	0
Average	**6.4**	**520**	**1093**	**623**	**54**	**10**	**76**	**61**	**95**	**54**	**4**	**1**
Load (kg/d)								1465	2285	1299	106	17
Fraction of total load							1.2%	2.5%	2.7%	5.1%	1.8%	1.1%
Total												
19/01/2011 17:00		250	387	130	38	8	6750	1685	2612	875	253	56
19/01/2011 19:00		210	405	212	38	8	6227	1306	2521	1322	234	47
19/01/2011 21:00		290	493	147	36	8	6206	1797	3062	912	225	53
19/01/2011 23:00		295	446	134	39	8	6268	1849	2796	840	245	51
20/01/2011 01:00		343	373	110	35	9	6419	2200	2394	707	223	58
20/01/2011 03:00		198	469	141	36	16	6093	1207	2856	860	222	96
20/01/2011 05:00		81	203	71	15	8	6061	492	1233	431	93	47
20/01/2011 07:00		899	1531	239	24	9	7034	6324	10770	1678	171	66
20/01/2011 09:00		510	485	102	38	9	6205	3165	3009	633	233	56
20/01/2011 11:00		643	526	187	44	10	6852	4403	3605	1280	299	71
20/01/2011 13:00		349	515	145	55	10	7210	2515	3713	1047	400	73
20/01/2011 15:00		279	636	323	47	16	6827	1905	4342	2205	318	112
Average		**362**	**539**	**162**	**37**	**10**	**6513**	**2404**	**3576**	**1066**	**243**	**65**
Load (kg/d)								57692	85825	25581	5829	1569

These results allowed to rebuild a composite sample that represents the raw wastewater to be treated at the plant. The characteristics of the raw wastewater are presented in Table 7. One could note that they significantly differ from the ones presented in Table 4.

Table 5 Composition of the raw wastewater (composite sample of "municipal" and "industrial" flows). NK value is estimated based on a NK/NH4 ratio of 3/2.

		Inlet
COD	mg/L	539
BOD5	mg/L	162
TSS	mg/L	362
NK	mg/L	*56*
NH4	mg/L	37
TP	mg/L	10
Temperature	°C	10 - 25
pH	-	*7.1*

Specific campaign by Seureca and ACC in May 2011

A measurement campaign was implemented from April 25th until May 19th 2011 to get a better knowledge of the characteristics of the incoming wastewater. The detailed results can be found in the report entitled "Analytical survey at Chisinau WWTP, presentation of the results, September 2011".

The composite samples were obtained through the installation of an automatic sampler at the second inlet chamber upstream the mixing of the raw "municipal" influent with the return stream of biological sludge and with the "industrial" sewer. The sampler collected a fixed volume of water every hour.

The main results of this campaign are presented in Table 6 Besides, it was noticed that:

- The influent is very septic, featuring very low ORP values and high sulphide concentrations.
- The influent is a typical diluted municipal wastewater.

Table 6 Composition of the raw wastewater (24h composite sample of the "municipal" flow only) in May 2011.

		Inlet
COD	mg/L	528
BOD5	mg/L	180
TSS	mg/L	208
TN	mg/L	53
NH4	mg/L	38
TP	mg/L	6
Temperature	°C	16 - 19
pH	-	7,7

Specific campaign by ACC in December 2011

ACC performed another specific campaign in December 2011 following the same methodology as for the one performed in May 2011 because ACC thought that the period of the measurement campaign in May was not representative of the standard situation due to the holidays during this period.

All analytical results obtained during this campaign are presented in Table 7, while the main results are summarized in Table 8.

Table 7 Detailed composition of the raw wastewater (24h composite sample, not flow weighted) at the inlet of the second inlet chamber

Date	pH	Alkalinity	PO_4^{3-}	P total	NH_4^+	N total	NO_2^-	NO_3^-	S^{2-}	Cr total	Iron total	Zn^{2+}	Cu^{2+}	Ni^{2+}	TSS	TS	COD	BOD5
Average	**7,4**	**22,37**	**11,3**	**3,75**	**40,3**	**44,51**	**0,09**	**0,19**	**1,2**	**0,08**	**1,11**	**0,04**	**0,03**	**0,05**	**288**	**772**	**535**	**222**
28/11/11	7,6	23,24	10,2	3,33	39,1	44,7	0,09	0,5	1,3	0,09	1,57	0,003	0,03	0,06	215	828	601	241
29/11/11	7,5	23,24	9,1	2,97	50,5	60,9	0,11	0,17							347	814	543	266
30/11/11	7,5	23,52	8,5	2,78	36,7	40,2	0,08	0,18							373	746	543	218
01/12/11	7,1	21,56	8,7	2,85	34,4	38,1	0,1	0,13							225	764	485	197
02/12/11	7,2	22,15	8,2	2,73	37,9	42,3	0,1	0,23							203	802	504	224
05/12/11	7,3	23,46	12,9	4,25	36,7	39,1	0,1	0,38	1,1	0,066	0,81	0,002	0,03	0,05	284	776	534	201
06/12/11	7,6	20,12	17,6	5,92	50,2	54,3	0,11	0,27							335	720	563	249
07/12/11	7,5	21,39	16,6	5,52	45,9	48,5	0,13	0,1							240	818	543	224
08/12/11	7,4	22,75	10,4	3,51	34,5	37,7	0,09	0,14							251	778	524	203
09/12/11	7,7	22,86	10,6	3,54	33,9	37,4	0,07	0,2							192	718	466	196
12/12/11	7,6	19,96	10,8	3,55	37,1	41,5	0,09	0,11	1	0,068	0,96	0,004	0,03	0,05	229	786	597	232
13/12/11	7,5	23,96	11,1	3,59	42,9	46,5	0,07	0,14							472	754	515	212
14/12/11	8,2	22,97	10,4	3,39	45,7	49,9	0,07	0,11							249	804	577	241
15/12/11	6,8	22,24	14,5	4,73	35,6	39,4	0,08	0,16							208	664	494	211
16/12/11	7,6	23,52	10,4	3,52	43,1	47,1	0,05	0,11							500	800	536	211

Table 8 Composition of the raw wastewater (24h composite sample, not flow weighted) in December 2011.

		Inlet
COD	mg/L	535
BOD5	mg/L	222
TSS	mg/L	288
TN	mg/L	45
NH4	mg/L	40
TP	mg/L	4
Temperature	°C	-
pH	-	7,4

2.3.1.2. Conclusions

The results of all above-mentioned measurement campaigns are summarized in Table 9.

Table 9 Summary table of the raw wastewater composition as measured in various measurement campaigns.

		Routine monitoring by ACC	Exceptional monitoring by ACC	Exceptional monitoring by ACC	Preliminary specific campaign	Specific campaign by Seureca and ACC	Specific campaign by ACC
		Upstream the sand removal tanks	"Municipal" only	Without sludge recirculation	Without sludge recirculation	"Municipal" only	"Municipal" only
		01/01/2010 - 30/09/2010	26/09/2005 - 30/09/2005	01/06/2009 - 24/06/2009	19/01/2011 - 20/01/2011	25/04/2011 - 19/05/2011	28/11/2011 - 16/12/2011
Average flow rate	m3/d	151 400	-	141 300	156 000	145 000	-
COD	mg/L	739	678	500	539	528	535
BOD5	mg/L	338	264	208	162	180	222
TSS	mg/L	542	525	278	362	208	288
NK	mg/L	56	NA	NA	56	53	45
NH4	mg/L	46	40	NA	37	38	40
TP	mg/L	9	7	NA	10	6	4
Temperature	°C	10 - 25	NA	19	-	16 - 19	-
pH	-	7,3	NA	NA	7,1	7,7	7,4
Alkalinity	mgCaCO3/L					136	224
		PO4	*PO4*			*TN*	*TN*

The different conditions (location of sampling, method of sampling, flow rate at the time of sampling, etc.) affecting each of these measurement campaigns make difficult the direct comparisons of these results. However, they show that the two most recent measurement campaigns are fairly consistent, especially for COD concentration, while significantly differing from the measurements recorded in the ACC routine monitoring in 2010. This observation confirms the fact that the way ACC monitors the quality of the raw wastewater is not well adapted and lead to the overestimation of the pollutants' concentration.

Based on the results presented in Table 9, the average water composition of the inlet to Chisinau WWTP presented in Table 10 has been proposed to serve as a basis for future design activities.

Table 10 Proposed current composition of the inlet to Chisinau WWTP

Parameter	Unit	Current values
COD	mg/L	530
BOD5	mg/L	200
TSS	mg/L	280
TN	mg/L	55
NH4	mg/L	40
TP	mg/L	6
Temperature	°C	10 - 25
pH	-	7.5
Alkalinity	mgCaCO3/L	200

Table 11 Ratios associated with the proposed inlet composition

COD/BOD	2,65
BOD/TSS	0,71
COD/TN	9,6
NH4/TN	0,73
COD/TP	88,3

The absolute pollutant concentrations of the influent (Table 10) show that the influent belongs to the moderate to diluted wastewater type, while the associated ratios (Table 11) indicate the probable presence of some organic matter difficult to degrade (COD/BOD > 2.5) and a future possible denitrification without the addition of an external carbon source (COD/TN close to 10).

Remarks:

- All NO3 and NO2 measurements in the raw wastewater have shown that the total concentration of oxidized forms of nitrogen is below 1 mg/L, thus TN can be approximated by NK without introducing a significant bias (Reminder: TN = KN + NO3 + NO2).
- The volume of wastewater (night soils) discharged at the WWTP by tankers has been assumed to be negligible.

2.3.2. PROJECTIONS

The change in consumption habits within the population of Chisinau is highly uncertain both in terms of content and evolution rate. This evolution is likely to lead to the increase of the pollutant concentration in the wastewater, all the more since intrusive water (IW) flow rates will progressively be reduced through the improvement of the sewerage network conditions. The intrusive water fraction is expected to decrease from 47% in 2010 down to 37% in 2020 and later (see wastewater collection network report). The associated concentration increase is presented in Table 12.

Table 12 Proposed future composition of the inlet to Chisinau WWTP (last column)

Parameter	Unit	Current values (with 47% of IW)	Theoretical values (with 0% of IW)	Future values (with 37% of IW)
COD	mg/L	530	1000	730
BOD5	mg/L	200	377	275
TSS	mg/L	280	528	386
TN	mg/L	55	104	76
NH4	mg/L	40	75	55
TP	mg/L	6	11	8
Temperature	°C	10 - 25	10 - 25	10 - 25
pH	-	7.5	7.5	7.5
Alkalinity	mgCaCO3/L	200	200	200

On the other hand, the pollution load originating from industrial customers is likely to decrease in the near future due to the stricter regulation and associated controls that should be implemented (see the report entitled “Assessment of industrial discharges, August 2011”). However the high uncertainty affecting the economic development of Chisinau and the implementation of stricter regulations do not allow to draw meaningful evolution of the future industrial discharge load to the municipal wastewater network. This statement and the fact that the industrial pollution load does not account for a significant fraction of the total pollution load make it reasonable to discard the marginal effect of the future evolution of the industrial pollution load when evaluating the future concentrations in the wastewater.

2.4. WASTEWATER FLOW RATES

2.4.1. CURRENT SITUATION

The wastewater flow rates at the inlet of Chisinau WWTP are recorded by flow meters that are located downstream the junction of the raw wastewater stream with the return streams, especially with the excess sludge return stream (Figure 2).

The estimated excess sludge flow rate has been subtracted to the measurements provided by the flow meters in order to get a more accurate picture of the raw wastewater flow rates. The excess biological sludge flow rate has been assumed equal to 250 m3/h (i.e. 6,000 m3/d) in standard operating conditions according to the plant operators.

The flow rates of other return streams have been considered negligible.

As illustrated in the inception report the wastewater flow rates have decreased by approximately 5% from 2008 until 2010.

The corrected wastewater flow rate measurements have allowed to draw fractile diagrams (Figure 5 and Figure 6). The main results are summarized in Table 13.

Table 13 Main results of the statistical analysis of the wastewater flow rates at Chisinau WWTP.

	Unit	Period 2008-2010
Average daily flow rate	m3/d	145,798
50%-fractile daily flow rate	m3/d	144,894
95%-fractile daily flow rate	m3/d	165,701
Average hourly flow rate	m3/h	6,083
50%-fractile hourly flow rate	m3/h	6,185
95%-fractile hourly flow rate	m3/h	7,573

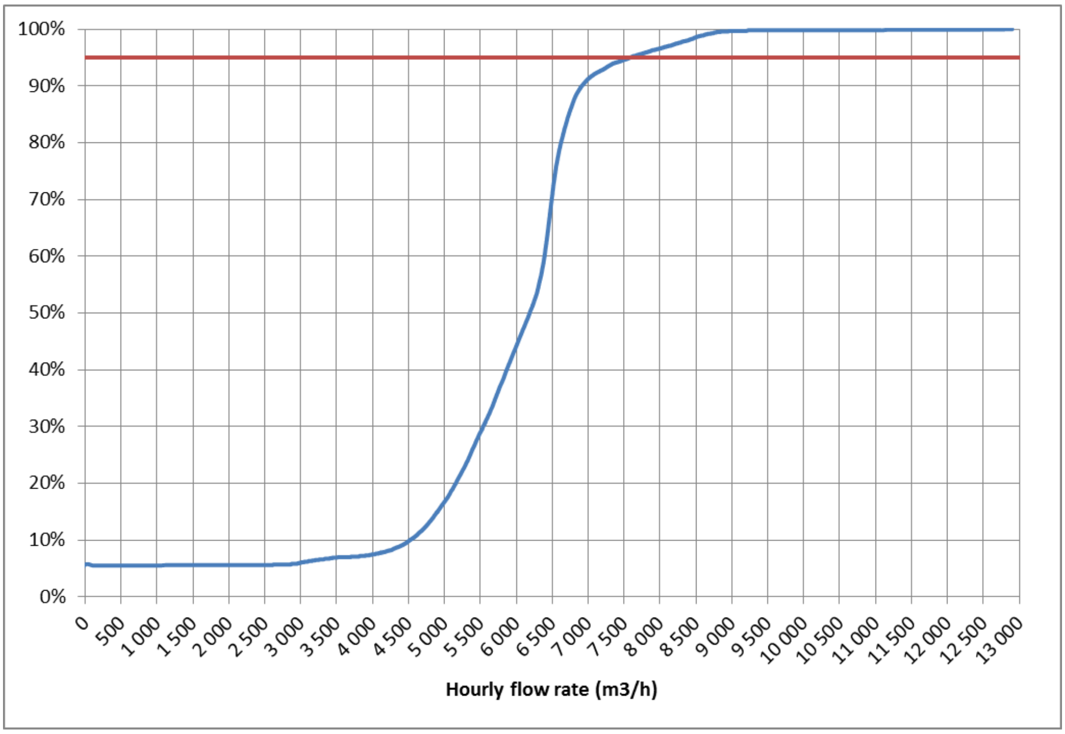


Figure 5 Fractile diagram for the hourly influent flow rate to Chisinau WWTP after correction (period 2008 – 2010)

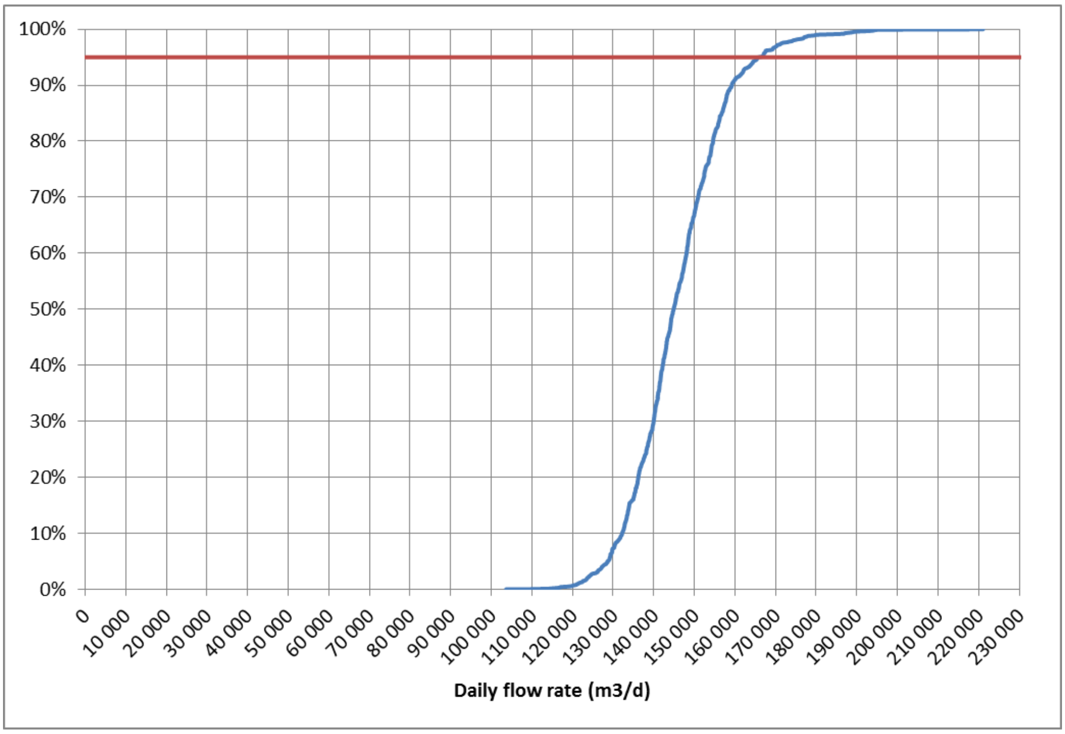


Figure 6 Fractile diagram for the daily influent flow rate to Chisinau WWTP after correction (period 2008 – 2010)

2.4.2. PROJECTIONS

The wastewater flow rates projections for the period 2010 – 2035 (reference: wastewater collection report) indicate a maximum average daily flow rate (ADWF) of approximately 160,000 m3/d in 2020 with an associated daily peak coefficient of 1.1 and an hourly peak coefficient of 1.4. The corresponding flow rates are presented in Table 14.

Table 14 Design figures for wastewater flow rates

		Unit	Maximum in the period 2010 - 2035
ADWF	Average Dry Weather Flow	m3/d	160,000
PDWF	Peak Dry Weather Flow	m3/d	176,000
PDWF	Peak Dry Weather Flow	m3/h	10,266

2.5. QUALITY OBJECTIVES

As explained in the inception report, the current allowed discharge limits set by the ecological department significantly differ from the European Urban Waste Water Treatment Directive (UWWTD, 91/271/EEC), whereas the EU regulation has been transposed into a Moldovan law and approved by the Moldovan government on October 10th 2008 (Hotarire Nr. 1141 din 10.10.2008 pentru aprobarea Regulamentului privind condiţiile de evacuare a apelor uzate urbane în receptori naturali - “Regulation on conditions for wastewater evacuation into the natural receivers”).

It has been decided to define the quality objectives for the treated wastewater at Chisinau WWTP in such a way that the EU regulation and the local environmental constraints are fulfilled, as explained in the below sections.

2.5.1. ENVIRONMENTAL CONSTRAINTS

The outlet of Chisinau WWTP is the Bic River. The flow rate of the river is controlled at the Ghidigici dam located upstream Chisinau city and has always been equal to or lower than the outlet flow rate of Chisinau WWTP since 2005.

As reported in the inception report, the quality of the Bic River just upstream the junction with the WWTP outlet is not good due to uncontrolled pollution by domestic and industrial discharges during its course through Chisinau city.

However, it has been assumed in the current evaluation that the situation is likely to improve through the implementation of the two following recommendations:

1. Ensuring a minimum flow rate of the Bic River higher than the current one (0.25 m3/s at the outlet of Ghidigici dam), which - for the average rainfall years - would increase the dilution factor at the outlet of Chisinau WWTP close to 2 or above during the Spring-Summer period which is most critical for aquatic fauna.
2. Improvement of the condition of the wastewater network and increase of the connection rates within Chisinau city, which would decrease the pollution of the Bic River.

Even when these measures will be effective, it is clear that the dilution of the outlet of Chisinau WWTP with the natural surface water of the Bic River will remain very low. Consequently and in addition to Carbon removal, Nitrogen and Phosphorus removal is necessary to avoid high concentrations of Nitrogen and Phosphorus containing compounds in the Bic River downstream the discharge point of the treated wastewater since these pollutants would prevent the good development of aquatic life in the Bic River and would also affect the surface water quality further downstream in the Dniester River during the period of low water and eventually also in the Black Sea. It is worth noting here that Romania considers all its water courses as sensitive areas.

These observations make it necessary to identify the Bic River as a "sensitive area" and therefore to apply the corresponding quality requirements to the outlet of Chisinau WWTP as defined in the EU regulation which are TN < 10 mg/L and TP < 1 mg/L (for WWTPs larger than 100,000 PE).

In addition to these requirements and considering the low dilution factor and the vulnerability of aquatic life to the toxicity of ammonium, it is proposed to also impose a maximum outlet concentration of 3 mg/L for NH4, which would make the final NH4 concentration in the Bic River downstream the discharge point lower than 1.5 mg/L (with a dilution factor of 2), which is acceptable for the development of aquatic life.

Besides, the Bic River is known to be used neither as a recreational area nor as a water supply for irrigation downstream the discharge point of the outlet of Chisinau WWTP. It is therefore not necessary to implement a final disinfection step of the treated wastewater.

2.5.1. EU REGULATION

The Bic River being considered as a sensitive water body and the capacity of Chisinau WWTP being larger than 100,000 PE, the requirements set by the EU regulation presented in Table 15 should be applied.

Table 15 Discharge limits for Chisinau WWTP (in accordance with the EU regulation for WWTPs of a capacity larger than 100,000 PE).

	Max. concentration (mg/L)	Min. removal rate (%)
BOD5	25	80
COD	125	75
TSS	35	90
TN	10	70
TP	1	80

2.5.2. FINAL QUALITY OBJECTIVES

Considering the EU regulation and the environmental constraints presented above, the final quality objectives for the wastewater treated at Chisinau WWTP are summarized in Table 16.

Table 16 Discharge limits for Chisinau WWTP

	Max. concentration (mg/L)	Min. removal rate (%)
BOD5	25	80
COD	125	75
TSS	35	90
TN	10	70
N-NH4	3	-
TP	1	80

3. CHISINAU WWTP DEVELOPMENT PLAN

3.1. INTRODUCTION

The current conditions of Chisinau WWTP and a list of proposed actions for the improvement of the WWTP operation and performances have been presented in the inception report.

There is no doubt that the short-term improvement measures cannot replace the long term - or preferably medium term - solution that consists in designing and constructing an entirely new WWTP. The new WWTP will eventually solve most of the issues that are currently experienced at the existing facilities both in terms of operational conditions (HSE, energy consumption, odour, etc.) and in terms of environmental protection (sludge treatment and disposal, final treated wastewater quality).

The objective of this section is to give more details about the solutions that could be part of the future design of the new WWTP. It aims at providing technical and financial elements to help decision-makers in their selection process of a new wastewater and sludge treatment plant.

A multi-criteria comparison of the various treatment options is provided so that a preferred solution can finally emerge.

3.2. WATER TREATMENT LINE

3.2.1. OVERVIEW OF THE EXISTING WATER TREATMENT LINE

The existing water treatment line of Chisinau WWTP has been described in the inception report and summarized in Section 2.2 of the present report. The main issues of the WWTP are the following:

1. The very poor conditions of the assets (both civil works and mechanical & equipment assets) make it necessary to design and build a new WWTP in the near future. This statement has been backed by the relevant observations reported in the inception report.
2. The current energy consumption can be significantly reduced by renewing inlet lifting pumps and air blowers (see Carbon report).
3. The current water treatment performances of the plant do not comply with the proposed discharge limits. The WWTP was designed for Carbon removal only – which is partially effectuated – and could also achieve nitrification since all operating conditions are met to do so but it appears that no nitrification occurs in the plant. This observation is discussed in the section below.

3.2.2. NITRIFICATION ISSUE

3.2.2.1. Who is guilty?

As presented in the report entitled “Analytical survey at Chisinau WWTP, presentation of the results, September 2011”, the operating values are in the range of the “very low load activated sludge” processes despite the fact that no nitrification occurs at Chisinau WWTP. This inconsistency required the in-depth investigations presented below.

Nitrification consists in oxidizing ammonium into nitrate following the simplified reaction:

$NH_4^+ + 2O_2 \rightarrow NO_3^- + 2H^+ + H_2O$

This reaction is performed by autotrophic bacteria, providing appropriate conditions allow them to develop in the activated sludge. These conditions are listed in Table 17. It should be noted that some conditions are mandatory for the development of the adequate fauna (F/M ratio) or for the very possibility of the reaction to occur (stoichiometry with alkalinity for instance), whereas other conditions (pH, oxygen, temperature, inhibitors) essentially affect the kinetics of the nitrification process, operating conditions outside the most favorable range will significantly reduce the reaction kinetics which will eventually result in very little or no nitrification at all in the activated sludge system if the hydraulic residence time of the water to be treated is not long enough.

Table 17 Check list to ensure nitrification can occur in a conventional activated sludge plant such as Chisinau WWTP

	Typical values	Verified at Chisinau WWTP?
Appropriate range of loading rate (F/M ratio)	< 0.2 kgBOD5/kgVSS/d	Yes
Sufficient alkalinity in the influent	> 200 mgCaCO3/L	Yes
Adequate temperature range	10 – 35 °C	Yes
Sufficient aeration	> 1 mg/L	Yes
Adequate pH range	7 - 9	Yes
Presence of inhibiting substances	Depending on the compound (Cu, Ni, Cr, Zn, Co, Phenol, CN, etc.)	?

The analysis of Table 17 shows that all operating conditions are fulfilled at Chisinau WWTP except the potential presence of inhibiting substances.

The nitrification process will not stop immediately after the contamination of the influent by an inhibiting substance but after a washout period of several weeks during which time the population of nitrifying bacteria will decrease. If the inhibiting substance is continuously present in the wastewater, then there is no chance for the nitrifying bacteria to develop at all in the activated sludge system.

The list of the nitrification inhibitors is very long but most common inhibitors that can sometimes be found in domestic wastewater are trace metals and specific compounds contained in industrial wastes such as phenol or various other hydrocarbons.

These compounds are generally seldom measured in the raw wastewater samples and the determination of the potential inhibiting substance(s) can be a very tedious job. Fortunately, it was found out that some of them are measured in the ACC routine analytical program. Trace metals do not seem to be in high enough concentration to inhibit the nitrification process, whereas cyanide concentrations appear to be in the range that can significantly affect this process, as explained below.

3.2.2.2. Cyanide could be the cause

Regulation related to cyanide

- Moldovan regulation

There is no MAC (Maximum Allowed Concentration) value for cyanide mentioned in the Decision 2/4 of Chisinau Municipal Council dated May 23rd 2002 on “improving the operation of sewage treatment plants and municipal sewer”. The industrial and domestic customers are therefore not constrained to fulfill any quality requirement about this parameter and consequently ACC does not perform any monitoring about cyanide.

- International practice

Commonly imposed restrictions on the discharge of industrial effluents to sewerage network sometimes include a restriction on hydrogen cyanide, but this inclusion and the associated limit value generally depends on the nature of the industrial activity at stake.

For instance, the limit set by United Utilities - a company that provides water and wastewater services in the industrial north west of England - is not greater than 1 mg/L since hydrogen cyanide is toxic and can inhibit treatment processes above this value.

Origin of cyanide

- Industrial activities

Industrial activities that generally utilize - and discharge - cyanide in their manufacturing process include electroplating, gold and silver mining, metal treatment, photographic processes, synthetic polymer and plastic industries, pesticides and rodenticides processing, leather processing, dying and other various laboratory activities.

- Industrial waste

The accumulation of cyanide containing waste is also a potential pollution point source if no proper leachate management is implemented. It is reported that large dump sites containing toxic waste – including cyanide – can be found in Moldova, as exemplified by Table 18 or by the communication presented by T. Galitcaia in 2004 who reported an amount of 6372.9 tons of waste containing cyanide in Moldova (NATO/CCMS Pilot Study: Prevention and Remediation - Issues in Selected Industrial Sectors: Rehabilitation of old landfills, Cardiff, Wales, May 23-26, 2004).

Table 18 Toxic waste stored on industrial sites in the Chisinau municipality (adapted from Moldova National Chemicals Management Case Study, Consultants Report, 16.04.2006, Milieu Ltd).

Toxic waste	Identified waste amount
Ferrocyanide	1083.87 t
Galvanizing sediment	320.66 t
Waste petroleum	360.64 t
Waste lead	236.88 t
Waste mercury containing lamps	633,841 units

Impact of cyanide on aquatic organisms

The following paragraph briefly present the impact of cyanide on aquatic organisms and is extracted from http://www.cyanidecode.org/cyanide_environmental.php.

"Fish and aquatic invertebrates are particularly sensitive to cyanide exposure. Concentrations of free cyanide in the aquatic environment ranging from 5.0 to 7.2 micrograms per liter reduce swimming performance and inhibit reproduction in many species of fish. Other adverse effects include delayed mortality, pathology, susceptibility to predation, disrupted respiration, osmoregulatory disturbances and altered growth patterns. Concentrations of 20 to 76 micrograms per liter free cyanide cause the death of many species, and concentrations in excess of 200 micrograms per liter are rapidly toxic to most species of fish. Invertebrates experience adverse nonlethal effects at 18 to 43 micrograms per liter free cyanide, and lethal effects at 30 to 100 micrograms per liter (although concentrations in the range of 3 to 7 micrograms per liter caused death in the amphipod Gammarus pulex).

Algae and macrophytes can tolerate much higher environmental concentrations of free cyanide than fish and invertebrates, and do not exhibit adverse effects at 160 micrograms per liter or more. Aquatic plants are unaffected by cyanide at concentrations that are lethal to most species of freshwater and marine fish and invertebrates. However, differing sensitivities to cyanide can result in changes to plant community structure, with cyanide exposures leaving a plant community dominated by less sensitive species.

The toxicity of cyanide to aquatic life is probably caused by hydrogen cyanide that has ionized, dissociated or photochemically decomposed from compounds containing cyanide. Toxic effects of the cyanide ion itself on aquatic organisms are not believed to be significant, nor are the effects of photolysis of ferro- and ferricyanides. It is therefore the hydrogen cyanide concentration of water that is of greatest significance in determining toxicity to aquatic life rather than the total cyanide concentration.

The sensitivity of aquatic organisms to cyanide is highly species specific, and is also affected by water pH, temperature and oxygen content, as well as the life stage and condition of the organism."

Inhibition of nitrification

- Literature review

Kim et al. studied the inhibiting effect of cyanide over the nitrification stage in the activated sludge process (Inhibitory effects of toxic compounds on nitrification process for cokes wastewater treatment, Kim et al., Journal of Hazardous Materials 152 (2008) 915–921).

"Free cyanide above 0.2 mg/L caused a distinct lag phase on nitrification in activated sludge. As free cyanide concentration increased, the length of lag phase increased and complete inhibition was reached at 1.0 mg/L of free cyanide. Similar results were reported by other researchers. Neufeld et al. [12] reported that maximum level of free cyanide to permit nitrification was 0.11 mg/L. Kim and Kim [16] reported that the increase of cyanide concentration (above 0.5 mg/L) produced excessive foam and decreased the microbial activity of activated sludge within the aeration tank, then the wastewater treatment process failed in operation due to poor settle-ability as well as sludge raising in a clarifier."

- Chisinau case

Some of the cyanide concentrations measured by ACC in the Bic River and in the outlet and outlet of Chisinau WWTP are displayed in Figure 7. The limit values of 0.2 mg/L (inhibiting effect starts) and of 1 mg/L (complete inhibition) reported by the literature have also been plotted to underline the fact that measured cyanide concentrations are right in the range of a significant inhibition effect not only in the inlet of Chisinau WWTP – which could be explained by industrial discharges to the sewer network – but also in the Bic River itself, confirming the poor ecological condition of this water body.

The detection of the continuous presence of cyanide at a concentration level that causes partial nitrification inhibition tends to indicate that cyanide could play a significant role in explaining the absence of nitrification observed at Chisinau WWTP although all other conditions are favourable to this microbiological process.

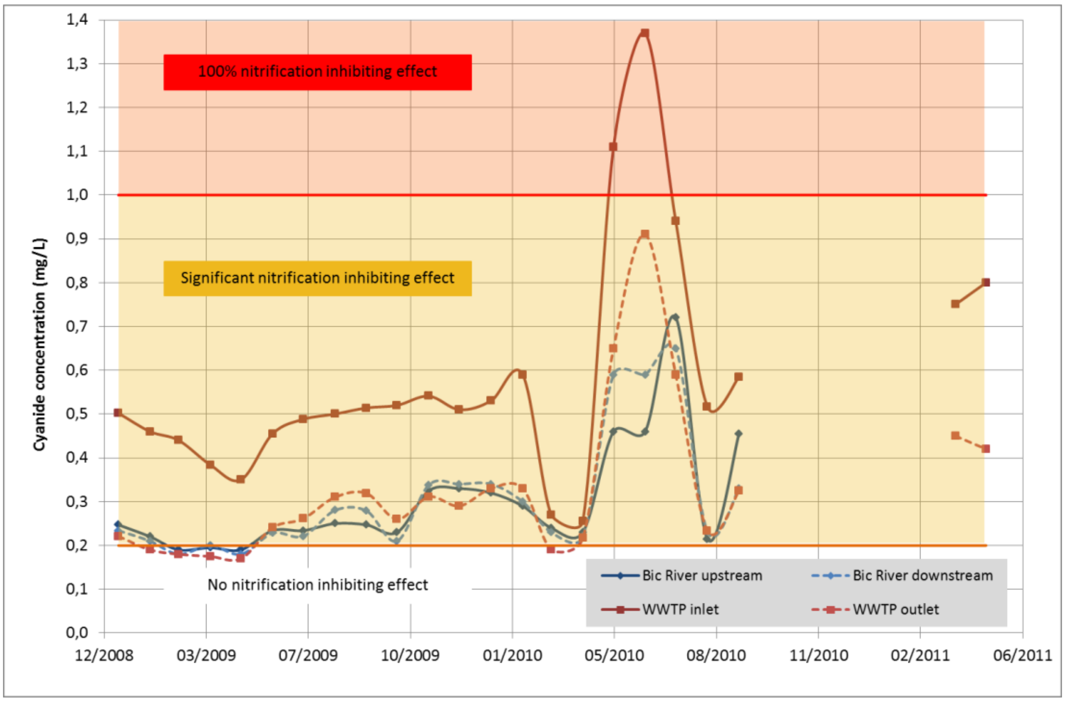


Figure 7 Cyanide concentrations measured by ACC in the Bic River upstream and downstream the discharge point of Chisinau WWTP and in the inlet and outlet of Chisinau WWTP.

Note:

Two different methods allow for the measurement of cyanides: free cyanide and total cyanides (complexed forms). These methods feature the same final detection method (colorimetric) but total cyanide measurement is preceded by a stage of digestion reaction (UV for instance) that breaks all complexed forms of cyanides into free cyanides. The first method said to be used by ACC does not feature this pretreatment and therefore correspond to the method for the measurement of free cyanides.

However a second method was later said to be applied that target the total cyanide concentration. The measurements presented above are said to be obtained through this second method, which would make the previous conclusions uncertain since the fraction of free cyanides included in the total cyanide measurements remains unknown.

It is therefore believed that further investigations are needed to better evaluate the correct free cyanide concentration in the wastewater prior to any further action aiming at removing nitrogen compounds from the wastewater.

3.2.2.3. What next?

The above-mentioned conclusion about the harmful presence of cyanide towards the nitrification process should not hide the fact that other inhibiting substances may be at stake. However, since the stricter discharge limits presented in Section 2.5.2 - and especially the limit values for TN and NH4 - make it necessary to ensure good nitrification at the future WWTP, one cannot do without further assessing the free cyanide concentrations in the wastewater and investigating the very origin of the cyanide pollution in the sewer network and possibly also in the Bic River. Once identified, these pollution sources should be removed and the wastewater composition carefully monitored to ensure that the cyanide concentrations go down to a level compatible with nitrification.

This task should be given high priority since it will be of no use to design and build a new WWTP without having completely solved this issue first.

3.2.3. FUTURE WORKS

3.2.3.1. Introduction and process selection

In addition to the characteristics of the wastewater and to the quality requirements and local conditions, the design of a new WWTP shall also take into consideration the following elements:

1. The existing facilities.
2. The strong interaction between the water treatment line and the sludge treatment line.

As previously discussed, it is believed that the implementation of a low load conventional activated sludge process (CAS) is the most adapted to the wastewater characteristics and quality requirements and local conditions due to the main following reasons:

- There is no space constraint (land is available on the premises of the existing WWTP and old drying beds).
- The operators already know the activated sludge process and the associated O&M procedures.
- The activated sludge process is robust.

3.2.3.2. Main water treatment steps in a CAS system

Pretreatment

Fine screening units aim at stopping medium and small particles (size ≥ 6 mm) to prevent problems (obstruction, blockage, clogging, etc.) in the following channels or pipes and avoid accumulation of these screenings in the tanks used for the wastewater treatment.

The influent contains some grit and grease which may create many problems throughout the treatment process. The grit may increase the tear and wear of the machineries and accumulate in the process tanks; the grease is detrimental to the oxygen transfer rate. Therefore grit and grease removal units must be implemented.

Primary settling

Depending on the characteristics of the raw wastewater and of the targeted treated water quality primary settling can be implemented to remove a large fraction of the suspended solids and of the pollution load, thus generating primary sludge that is transferred to the sludge processing unit. In the case of Chisinau, primary settling is not recommended since low load activated sludge is targeted to achieve a very high removal efficiency which would be prevented by a primary settling stage that reduces the C/N ratio.

Biological treatment

Downstream the primary settling tank, the pollution removal shall be completed with a biological treatment in order to meet the final discharged effluent quality requirements. Based on the oldest process to treat municipal and industrial wastewater, the activated sludge process has been optimised to provide an extremely cost-effective treatment of wastewater.

The concept of a Conventional Activated Sludge (CAS) process consists in promoting the development of a concentrated biomass (a consortium of bacteria) in a tank where the wastewater is contacted with the bacteria, thus forming what is referred as the “mixed liquor (wastewater and biomass).

It is necessary to aerate the biological tanks to provide the oxygen required to keep alive the bacteria and to allow them to grow and degrade the pollution load. The aeration also helps to mix the mixed liquor (i.e. the mix of biomass and wastewater).

The average age of the bacteria present in the system is called “sludge age”. It is an important design and operating parameter which, together with the concentration of biomass in the biological tanks and the operating conditions (temperature, dissolved oxygen concentration, etc.) allows for the sole degradation of carbonaceous organic matter (medium-load activated sludge, >90% carbon removal efficiency) or the degradation of carbonaceous and nitrogen pollution in case a long sludge age and adequate process conditions are ensured (low-load activated sludge, >95% carbon removal efficiency). Phosphorus removal –when required – can be achieved either by physico-chemical treatment (precipitation of phosphates followed by sedimentation) or by biological treatment (by exposing the biomass to alternated aerobic and anaerobic conditions).

Secondary clarification

The last step of a conventional activated sludge process train consists in separating the solid phase (the biomass) from the liquid phase (the treated wastewater). This step is performed in secondary clarification tanks where the suspended solids (forming the biological sludge) settle at the bottom of the tank and the clarified treated water leaves the tank at the top.

Most of the secondary (or biological) sludge is recycled to the biological tanks to ensure a constant active biomass into the whole system while the remaining fraction (excess sludge) is wasted and transferred to the sludge processing unit.

3.2.3.3. C, N and P removal

The most comprehensive biological treatments target the removal of carbon, nitrogen and phosphorus compounds from the wastewater. Nitrogen is mostly present in the form of ammonium ions (NH_4^+) in the raw wastewater. It is first oxidised by autotrophic bacteria into nitrate ions (NO_3^-) in oxic conditions and further reduced by specific bacteria into nitrogen gas (N_2) in anoxic conditions. Phosphorus can be removed by a physic-chemical reaction - precipitation of phosphates with a specific coagulant agent such as $FeCl_3$ followed by settling - or by a biological mechanism which requires to expose the mixed liquor to alternating aerobic and anaerobic conditions. In these conditions specific bacteria accumulate the phosphorus thus transferring the phosphorus from the liquid phase (wastewater) to the solid phase (biomass/sludge).

3.2.3.4. Process design

Treatment line

In the case of Chisinau, the treatment of C, N and P is targeted. The recommended process is a low load activated sludge due to its robustness and simplicity compared to other processes.

This wastewater treatment scheme includes the following elements:

- Reception platform and equalization/storage tank for night soils and other wastewater brought to the plant by trucks
- Coarse screening (30 mm)
- Pumping station
- Fine screening (6 mm)
- Sand and grease removal tanks
- Biological tank featuring a contact zone followed by a strict anaerobic zone (intended for biological P removal) and a large tank with intermittent aeration (to account for anoxic and aerated periods) and injection of FeCl3 (for physico-chemical P removal)
- Secondary clarifier

Calculations

The calculations regarding the biological treatment are presented in Table 19. Their analysis necessitates the following clarifications.

Alkalinity in the influent is a limiting factor to full nitrification and therefore lime addition should be planned.

Temperature plays an important role in the biological processes, low temperatures significantly reducing the kinetics of the biological reactions. It appears that a limit value of 12 °C of the raw wastewater should be set up; below this value discharge limits for nitrogen compounds could be exceeded, providing the annual average value for TN and NH4 are within the acceptable range fixed by the regulation.

Table 19 Process design calculations (with injection of external carbon source)

Temperature	°C	12
Average daily flow rate	m3/d	160000
Peak factor	-	
Contact zone	m3	3000
Anaerobic volume	m3	16000
Anoxic volume	m3	75000
Aerated volume	m3	140000
Total volume	m3	234000
Aeration	-	Air diffusers
Oxygen concentration in aerated zone	mg/L	2
Sludge age	d	16
Mass load	kgBOD5/kgVSS/d	0.072
Volume load	kgBOD5/m3/d	0.188
Concentration of activated sludge	g/L	4.3
Effluent quality		
COD	mg/L	53
Total N	mg/L	9.8
NO3	mg/L	4.3
NH4	mg/L	2.3
Total P	mg/L	0.8
Aeration		
Oxygen demand	kgO2/d	80565
Peak oxygen demand	kgO2/h	4847
SAE in activated sludge	kgO2/kWh	2
Aeration power to be installed	kW	2424
Sludge production		
Daily mass of produced sludge	kgTSS/d	62266
VSS	%	61
TSS concentration of the effluent	mg/L	15
TSS concentration of extracted sludge	g/L	8.6
Daily mass of extracted sludge	kgTSS/d	59866
Flow rate of extracted sludge	m3/d	6961

Energy consumption

The energy consumption due to aeration of the whole future WWTP is estimated at around 50,000 kWh/d.

The total energy consumption of the plant is estimated at around 70,000 kWh/d.

Land requirement

The approximate dimensions of the biological tanks and of the secondary clarifiers are presented in Table 20 while a more global estimation of the land requirement for the whole WWTP is displayed in Table 21.

Table 20 Approximate dimensions of the biological tanks and of the secondary clarifiers

Biological tanks		
Total biological volume	m3	249000
Number of biological tanks	-	12
Volume of each biological tank	m3	20750
Depth of each biological tank	m	7
Area of each biological tank	m2	2964
Width of each biological tank	m	24
Length of each biological tank	m	124
Secondary clarifiers		
Peak velocity	m/h	0,8
Max hourly flow rate	m3/h	10266
Area needed	m2	12833
Number of clarifiers	-	9
Area of each clarifier	m2	1426
Diameter of each clarifier	m	42,6
Depth of each clarifier	m	3,5

Table 21 Dimensions of the main works for one wastewater treatment train (sludge treatment excluded)

	Number of units -	Total area m2
Pumping station and pretreatment	1	1,000
Reception platform and storage tank for night soils	1	500
Biological tanks (7 m deep)	12	44,000
Secondary clarifiers	9	25,000
Mechanical thickening and dewatering, liming, chemical storage, etc.	1	1,000

The total land requirement for the whole WWTP and the associated buildings is then estimated at 8 ha.

Figure 8 gives an example of where such a WWTP could be implemented in the existing premises.

Figure 8 Possible location of the future WWTP (Blue rectangle: 400 m x 200 m)

3.2.3.1. Financial elements

An estimation of the CAPEX and OPEX of the basic solution as described above is presented in Table 22. This estimation includes sludge thickening and dewatering by centrifugation but does not include further sludge treatment.

Table 22 CAPEX and OPEX estimates for the basic option

CAPEX (million MDL)	842
OPEX (million MDL/year)	62
Energy	35
Human resources	13
Others (chemicals, drinking water)	14
Maintenance and renewal (million MDL/year)	20

3.2.3.2. Phasing

The BOD load that was treated in 2010 at Chisinau WWTP is around 29,200 kgBOD/d (200 mgBOD/L x 146,000 m3/d) while the maximum future load (in 2020) was estimated in Section 2.3 at 44,000 kgBOD/d (275 mgBOD/L x 160,000 m3/d). This represents an increase of about one third.

It is recommended to phase the future works in order to deal with the uncertainties of the predictions and to be able to adjust the works when more precise information are available.

As presented in Table 20, it is recommended to divide the future WWTP into three independent treatment trains - each of them being able to treat about 15,000 kgBOD/d and 53,000 m3/d. two trains would then roughly correspond to the current (2010) pollution and hydraulic load treated at Chisinau WWTP, while the third train would allow to treat the additional load expected in 2020.

Considering the conditions of the current facilities, the recommended phasing is presented in Table 23. This phasing does not take into account the future final sludge treatment but includes the necessary first stages of sludge treatment (thickening and dewatering and anaerobic digestion). It also includes the works associated with odor reduction, such as biological air filters for the pretreatment works and chemical scrubbers for the dewatering and intermediate sludge storage facility.

Table 23 Recommended phasing of the investment (without final sludge treatment)

	Civil works	Equipment	CAPEX (million EUR)
Priority investment program (2012)			26.6
New pretreatment building (coarse screening, pumping, fine screening, sand and grease removal tanks)	100%	66%	7.4
Rehabilitation work for the medium load wastewater treatment line	-	20%	3.8
Sludge treatment line	100%	100%	11.9
Electrical works	100%	33%	3.5
Future investment (Phase 1 – 2015)			24.0
Biological tanks	67%	47%	5.7
Secondary clarifiers	67%	67%	6.4
Thickeners	67%	67%	2.8
Electrical works	0%	33%	3.1
Administrative building and miscellaneous works	100%	100%	4.9
Future investment (Phase 2 – 2018)			12.7
Pretreatment	0%	33%	1.6
Biological tanks	33%	33%	3.4
Secondary clarifiers	33%	33%	3.2
Thickeners	33%	33%	1.4
Electrical works	0%	33%	3.1

3.2.3.3. Priority investment program (PIP)

Considering the high CAPEX required to upgrade the WWTP in order to achieve N and P removal and the implementation time to get the funding and commission the new plant, it is proposed to do the necessary rehabilitation works on the existing wastewater treatment line in order to secure good performances of the plant without changing its current objective (C removal only, thanks to a medium load activated sludge process) and to include anaerobic sludge digestion into the PIP. The main reasons for including anaerobic sludge digestion are the following:

- It would allow to decrease the sludge volume by reducing by 1/3 the amount of dry solids and by reaching higher dryness (around 28% with the centrifuge to be compared to 22% without digestion and 17% with the current Geotubes). The implementation of the whole project could be a long process in particular to obtain sovereign guarantees and getting EU grants. Considering the limited storage capacity for sludge at the WWTP (4 years only), priority should be given to reduce the volume of sludge in the PIP.

- Anaerobic sludge digestion would provide a stabilized sludge. Today the sludge is not stabilized which is one of the source of odour. Stabilization with lime is possible but the risk is that it would not be acceptable for sludge use in agriculture since the soils are said to be already alkaline. Anaerobic sludge digestion is compatible with sludge use in agriculture and will reduce the volume and cost of transportation.

- The production of biogas and the associated energy recovery would cover more than 50% of the energy production of the WWTP (inclusive of the raw pumping station). Part of the investment concerning energy recovery has already been done since the existing co-generation facility could be reused.

- Lastly the production of biogas from sludge would make the project a green investment more likely to be supported by the international funding agencies.

It must be noticed that the implementation of sludge digestion requires making priority investment on the water treatment works of the WWTP in order to secure the treatment process, i.e. the quality of treated water and a steady production of sludge.

Before a complete renewal, Chisinau WWTP would work under the current medium load activated sludge process. However renewal of air blowers – to increase energy efficiency – but also the renovation of existing primary settlers, aeration tanks and secondary clarifiers are necessary to yield the expected sludge and send it for digestion.

It must be stated that the PIP does not include the investment required to treat nitrogen and phoshorus. The WWTP will only treat carbon pollution. The full compliance of the WWTP with EU standards for Nitrogen and Phosphorus exceeds by far the investment capacity of ACC for the time being.

However, the implementation of sludge digestion is compatible with a future complete overhauling of the water treatment, to achieve nitrogen and phosphorus treatment.

The breakdown of the PIP for Chisinau WWTP is provided in Table 24.

Table 24 Details of the priority investment program (in EUR) for Chisinau WWTP (grey cells correspond to investments that will not be reused in the future phases of the WWTP development)

	Civil works	Equipment
Rehabilitation work for the medium load wastewater treatment line		
Raw water pumps renewal / inlet structures	1,500,000	1,600,000
Pretreatment	2,400,000	1,900,000
Renovation of primary settlers	100,000	440,000
Retrofitting of 4 "small" aeration tanks - medium load	500,000	
Renewal of air blowers - medium load		1,100,000
Rehabilitation of the 5 currently operated secondary clarifiers	150,000	770,000
Rehabilitation of one additional secondary clarifiers (not in use)	175,000	308,000
Rearrangment of sludge recirculation		220,000
New works for the sludge treatment line		
Implementation of separated thickening for biological excess sludge	15,000	550,000
Mixing tank	30,000	200,000
Digesters - 27 000 m3 (3 x 7,700 m3)	4,200,000	2,227,000
Biogas treatment and CHP units (existing)		200,000
Dewatering (centrifuge)	1,500,000	3,010,000
Electrical works		3,500,000
Total	**10,570,000**	**16,025,000**

The implementation of the proposed PIP would allow to decrease the annual OPEX related to energy purchase by about 11.5 million MDL while the annual OPEX for polymer would increase by 5 million MDL (Table 25).

Table 25 OPEX of Chisinau WWTP

	2008-2010	After PIP
Energy for wastewater treatment	11.5 GWh/year	11.5 GWh/year
Energy for pumping	5.3 GWh/year	2.1 GWh/year
Energy for sludge treatment	Negligible (Geotubes)	3 GWh/year
Recovered energy from digestion	0	8.4 GWh/year
OPEX energy	22.5 million MDL	11 million MDL
Polymer for sludge treatment	30 t/year (Geotubes)	110 t/year (centrifuges)
OPEX polymer	1.9 million MDL	6.9 million MDL

3.2.4. COMPARISON OF VARIOUS TREATMENT LINES

3.2.4.1. Treatment schemes

The following sections present a comparison between three alternatives for the renewal of Chisinau WWTP. These alternatives feature a low load activated sludge process as the main treatment process for wastewater treatment but differ from each other through the targeted treated water quality and the addition of anaerobic sludge digestion. A brief description of the three options is provided below:

- Option 1 features a low load activated sludge process without primary settling tank and without anaerobic sludge digestion; the targeted water quality being 10 mg/L for TN and 1 mg/L for TP (Figure 10).
- Option 2 features a low load activated sludge process with primary settling tank and with anaerobic sludge digestion; the targeted water quality being 10 mg/L for TN and 1 mg/L for TP (Figure 11).
- Option 3 features a low load activated sludge process with primary settling tank and with anaerobic sludge digestion; the targeted water quality being 15 mg/L for TN and 2 mg/L for TP (Figure 11).

For comparison purposes the current treatment scheme of Chisinau WWTP is presented in Figure 9.

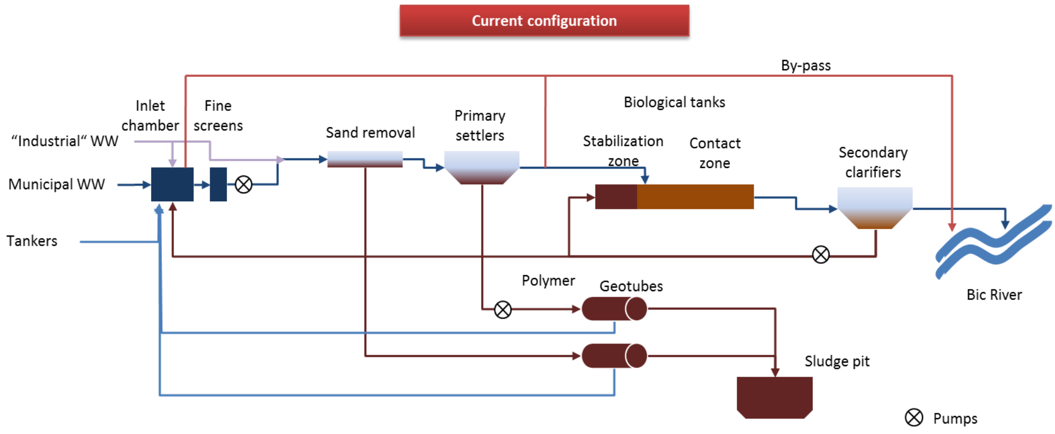


Figure 9 Treatment scheme of the existing Chisinau WWTP

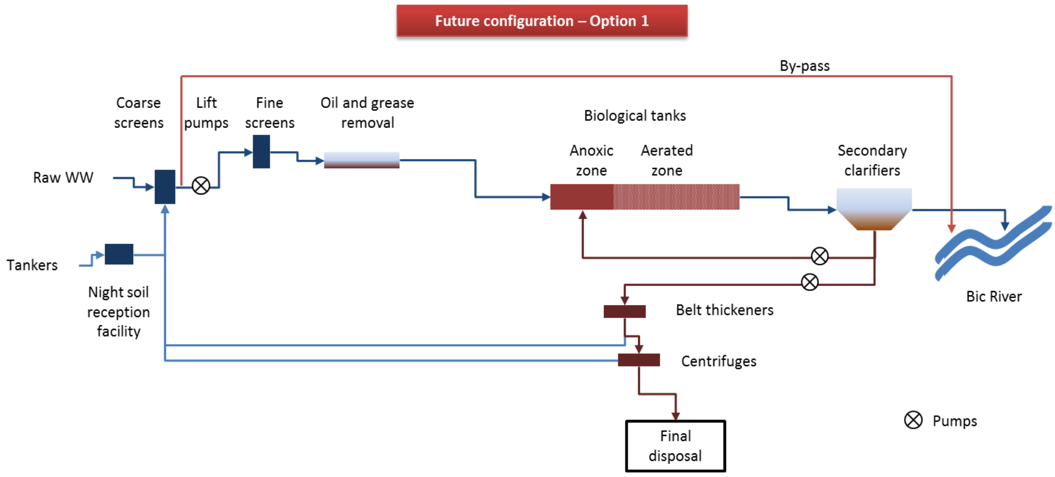


Figure 10 Treatment scheme of the future WWTP – Option 1

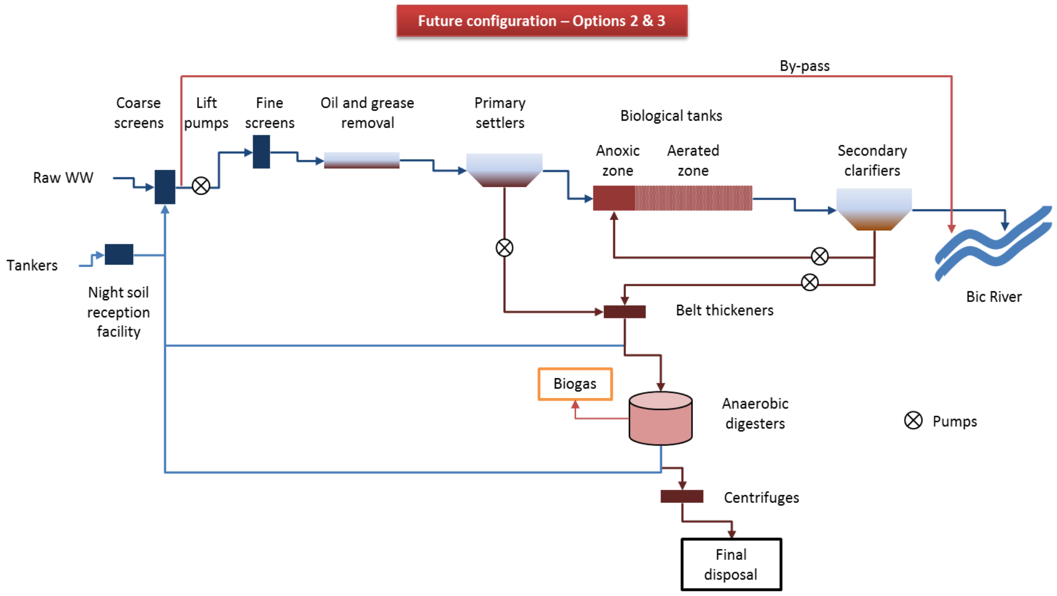


Figure 11 Treatment scheme of the future WWTP – Options 2 & 3

3.2.4.2. CAPEX and OPEX estimations

An estimation of the CAPEX and OPEX of the three options presented above is presented in Table 26. These estimations show that the CAPEX of Option 2 and Option 3 is very similar and approximately 350 million MDL higher than the CAPEX of Option 1 due to the extra facilities to be constructed in comparison to Option 1. These facilities include the primary settling tanks, the digesters and the associated CHP unit.

However, it appears that the extra cost of the additional injection of chemicals in Option 3 and Option 4 (methanol, ferric chloride and polymer) compared to Option 1 is compensated to a large extent by the gain in electricity cost originating from the electricity produced by the biogas turbines. Eventually, the OPEX of Option 2 and Option 3 is approximately 28 million MDL per year lower than in Option 1.

It should be kept in mind that this result has been obtained by applying the two following hypothesis:

- The costs of energy and chemicals only have been taken into account in the OPEX calculations. It is obvious that extra operating staff will be required in case of Option 2 or Option 3 to cope with the operation tasks induced by the extra facilities (primary settling tanks, digesters and CHP unit).
- The OPEX has been calculated based on a list of unit costs that is thought to be representative of the Moldovan context (Table 27).

Table 26 Comparison of the three treatment options

	Unit	Option 1	Option 2	Option 3
TN/TP target in the treated water	mg/L	10 – 1	10 – 1	15 – 2
Anaerobic digestion	-	No	Yes	Yes
CAPEX				
Pretreatment	million MDL	144	144	144
Primary settlers	million MDL	0	74	74
Biological tanks	million MDL	163	180	165
Secondary clarifiers	million MDL	154	154	154
Belt thickeners	million MDL	50	80	80
Digesters	million MDL	0	144	144
CHP unit	million MDL	0	56	56
Centrifuges	million MDL	91	110	110
Electrical plant	million MDL	161	178	178
Miscellaneous	million MDL	79	87	87
Total	**million MDL**	**842**	**1,207**	**1,192**
OPEX				
Methanol consumption	kg/d	0	1,499	1,506
Methanol cost	million MDL/year	0	1	1
Pure FeCl3 consumption	kg/d	4,112	8,672	5,881
FeCl3 (41%) consumption	kg/d	10,029	21,151	14,344
FeCl3 (41%) cost	million MDL/year	8	17	12
Polymer consumption	kg/d	250	310	290
Polymer cost	million MDL/year	6	7	7
Total energy consumption	kWh/d	71,375	63,033	62,423
Energy produced	kWh/d	0	34,732	34,546
Energy required	kWh/d	71,375	28,301	27,877
Energy cost	million MDL/year	35	14	14
Total (energy + chemicals)	**million MDL/year**	**49**	**21**	**20**

Table 27 Hypotheses for unit costs of chemicals and energy

	Unit	Cost
Methanol	MDL/t	2,500
FeCl3 (41%)	MDL/t	2,200
Polymer	MDL/kg	63
Energy	MDL/kWh	1.34

3.2.4.3. Suitability with final sludge disposal option

There is a strong connection between the final sludge disposal scheme and the wastewater and sludge treatment. For instance it is not relevant to implement a sludge incineration plant downstream a sludge treatment line featuring an anaerobic digestion step since the fraction of organic matter will be reduced at the inlet of the incineration. Thermal oxidation of sludge will then require additional fuel.

Another example of this strong dependency can be found when looking at the agricultural use of sludge. Organic matter and nutrients (N and P) are valuable contents of the sludge for the plants and both digested and non-digested sludge contain these constituents although digested sludge will have less organic matter. In addition, digested sludge does not require further hygienisation whereas non digested sludge may require additional liming that could also bring some mineral material to the soils if needed.

The suitability of the treatment options discussed above is qualitatively assessed in Table 28.

Table 28 Suitability of WWTP options with final sludge disposal option

	Option 1	Option 2 & Option 3
Incineration	+	-
Landfill	+	+
Agricultural use	+	+
Use in cement factory	+	-

3.2.4.4. Recommendations

Considering the priorities which have been taken into account to derive the recommended PIP featuring anaerobic digestion and the fact that it is cost efficient to reuse the maximum of available structures in good conditions – the new anaerobic digesters will be the only ones - Option 2 appears to be the preferred option for the future design of the new WWTP to be built.

Consequently the final disposal sludge option will preferably be landfilling or agriculture use. The latter will be advantageously applied when all local conditions for its implementation are met.

3.3. Sludge treatment line

3.3.1. Overview of the existing sludge treatment line

The existing sludge treatment process consists in the dewatering of mixed sludge (primary and biological sludge) pumped from the primary settling tanks to Geotubes, where it is mixed with polymer and kept for approximately 2 months.

The Geotubes were implemented in September 2009 by ACC as a quick and easy attempt to mitigate odour issues generated by the sludge drying beds. This proved to be quite efficient since it has been reported that this modification led to a significant reduction of odours.

There is a total of 93 Geotubes installed on site, which covers approximately 3.6 ha. Each of them has a capacity of 600 m3 and cost 3,500 € each. This figure is comparable to the average salary of one worker which is about 3,600 €/year.

The dewatering cycle is about 2 months and one Geotube is emptied every three days. Thus the OPEX of this dewatering system can be estimated as 420,000 €/year (120 Geotubes).

The sludge dryness is between 15% and 20% after dewatering in the Geotube. Geotubes are opened and the dewatered sludge is taken away by trucks to a landfill site (2 ha) which is located 200 m far from the drying beds (32 ha). The landfill site is still within the plant boundary but was planned to be full in February 2011.

240,000 m^3 of sludge were transferred from the drying beds to the landfill site in 2010 to make room for the Geotubes.

The Geotubes generate approximately 87,000 m3/y of sludge. At 20 % dryness this equals to 17,400 tDS/y or 48 tDS/d. This is coherent with the assumption that one Geotube (600 m3, 20% dryness) is filled in 3 days (which gives a sludge production of approximately 40 tDS/d).

The leachates are collected via a drainage system and transferred to the second inlet chamber.

Geotubes with sludge feeding line.

Opened Geotube prior to sludge handling.

Sludge is taken out of the Geotubes and transported to a final disposal site nearby.

The sludge is finally disposed of in a landfill located nearby. However, the landfill being full, new pits have been dug on the WWTP premises to temporarily store the sludge in a near future. One pit of 200,000 m3 is already in operation, while the second one (150,000 m3) is almost finished (Figure 12). It is intended to store the sludge for 2 years in the pit before final disposal, which is expected to be done in coordination with a state company in charge of growing trees. The entire sludge disposal route has not yet been implemented.

Figure 12 Construction of a sludge pit (November 2011) at Chisinau WWTP. Geotubes can be seen in the background.

3.3.2. SLUDGE DIGESTION

3.3.2.1. Anaerobic sludge digestion

Chisinau WWTP originally included a digestion and cogeneration facility. This facility was never used due to structural defaults of the digesters. Revamping the existing digesters is very likely to be more expensive than constructing new ones.

The implementation time of such a treatment line would be longer than the one required for sludge thickening and dewatering alone but sludge digestion would be very beneficial for the following reasons:

- Reduction of the final amount of sludge to be disposed of
- Energy generation
- Reduction of GHG emissions

A co-generation plant is operational on-site. It was built by a private investor (Energy investment group) who went bankrupt due to the increase in gas price. It was initially planned to use the biogas produced by the digesters. Then natural gas was used since no biogas could be produced. After the bankruptcy, the facility was taken by the bank. It is now the property of the bank and is not in use today.

ACC would be authorized to produce the energy required to cover its own energy needs, but would not be authorized to sell the surplus to customers by the existing Moldovan laws.

3.3.2.2. Principle and benefits of sludge digestion

The technology in brief

Sludge digestion consists in pumping the sludge to a sludge digester, which is a closed and heated tank. No air can enter the tank and the temperature is maintained at around 35°C (in case of a mesophilic digester). The sludge retention time in the digester is generally between 20 to 30 days.

Under these anaerobic and warm conditions, fermentation of the degradable organic matter can occur. Some anaerobic bacteria will develop and degrade the organic matter. Instead of producing only carbon dioxide (CO_2) as aerobic bacteria do, anaerobic bacteria produce some methane (CH_4). In fact the mixture of bacteria that is present in the sludge digester produces a mixture of gases, of which the majority will be methane (around 60 to 65 %). Methane is an energetic gas (it is the same as natural gas) that can be burnt in a boiler or in an engine, to produce energy.

Figure 13 displays the principle of sludge digestion and its two main advantages: reduction of the volume of sludge and production of energy.

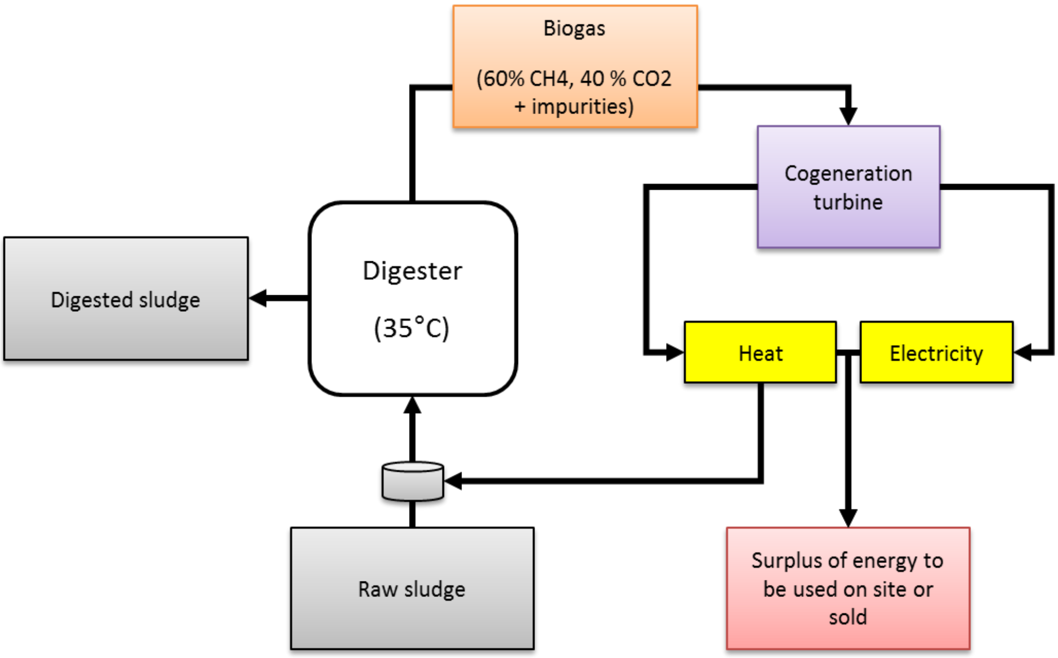


Figure 13 Principle of sludge digestion with energy recovery

Benefits of sludge digestion

Digestion is environmentally friendly, reduces the emissions of greenhouse gases (GHG), has a green image and is one of the Best Available Technologies for sludge treatment.

- Reduction of the volume of the sludge and associated costs

Digestion reduces the volume of sludge to be disposed of by around 30 %, which consequently reduces the associated costs of downstream sludge treatment. That is why the solution is financially relevant on a long term basis for large WWTPs.

- Production of energy

Sludge contains energy (organic matter) and water; but it requires a lot of energy to separate the organic matter from the water (for example by centrifugation or evaporation). On the contrary, during anaerobic fermentation the bacteria themselves are separating the energetic content of the sludge (transformed into methane gas) from the water. This is the main advantage of sludge digestion. No energy is consumed to recover the energy of the sludge itself, except for a very small percentage required for the heating of the digester.

Generally speaking, the amount of biogas produced on a WWTP allows to cover all heating requirements and a substantial part of the electricity requirements.

3.3.2.3. Production of heat and electricity

A Combined Heat and Power (CHP) unit is an engine that accepts gas as a fuel, and produces electricity (by rotation of the alternator) and heat (by recovery of calories on the engine cooling system and on the exhaust fumes).Heat is produced as hot water (usually 90 °C). Part of the heat can also be recovered as steam (on the exhaust gases).

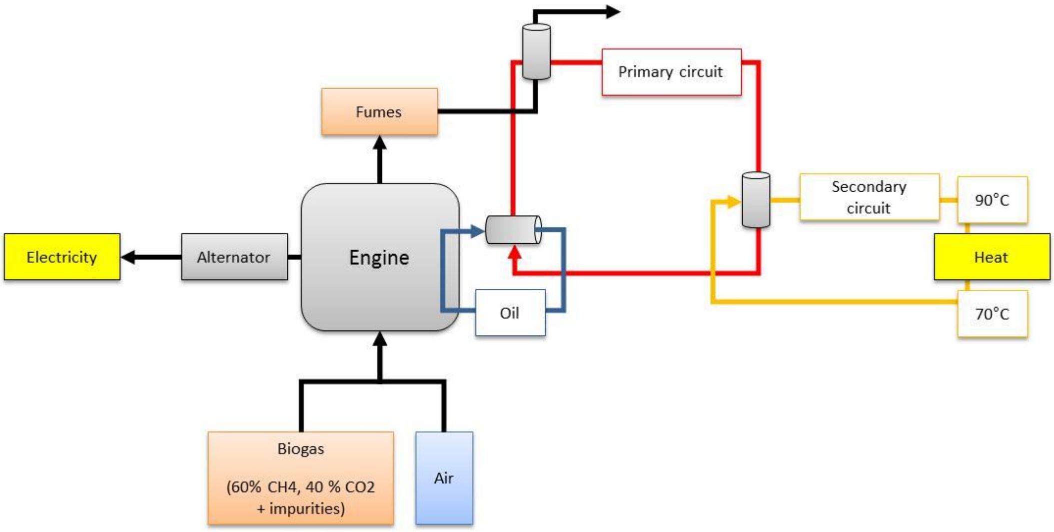


Figure 14 Combined Heat and Power engine: generation of electricity and heat from biogas

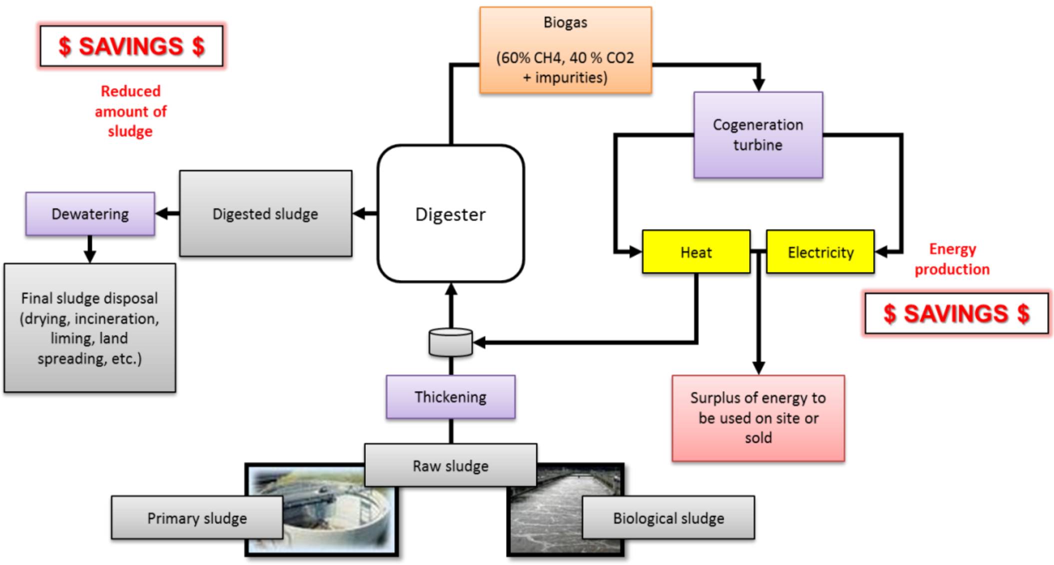


Figure 15 The two main benefits of sludge digestion are production of energy and reduction of sludge volume for final treatment and disposal

3.3.2.4. Design criteria and hypotheses

Types of sludge

Sludge digestion is more efficient when the sludge contains a large fraction of degradable organic matter. Otherwise the bacteria will face difficulties to 'digest' the organic matter.

That is why sludge digestion is preferably applied for primary sludge, or for high load activated sludge or for mixed sludge (mix between primary and secondary sludge). The digestion of low load activated sludge or very low load activated sludge displays a low efficiency. However it is possible to use specific technologies to enhance the yield of sludge digestion on low load sludge by advanced sludge pretreatment (hydrolysis).

In addition, it is not recommended to implement sludge digestion when biological phosphorous removal is implemented in the waste water treatment process since phosphates are released during the digestion stage and sent back to the head of the plant with the sludge centrates.

Particulate nitrogen will also be hydrolyzed during the digestion process and the ammonium load of the sludge centrates is generally high and should be taken into consideration when designing the waste water treatment line.

Figure 16 Digesters at Prague WWTP (Czech Republic)

Design of digestion

A sludge digester is designed on a retention time, which is set at around 20 days. For example, 100 m3/d of sludge will be digested in a 2,000 m3 digester.

Yield

The yield of sludge digestion is calculated on the organic part of the sludge only, because only organic matter is degraded. Typical yield is around 45-50% for a mixed sludge with a 20 to 30 days retention time in the digester. It means that only 50% of the organic matter of sludge is bio-degradable in less than 20 to 30 days. Yield is around 50-60% for primary sludge and only 25-40% for biological sludge.

The production of biogas from sludge digestion varies according to the type of sludge. The order of magnitude is around 800 to 900 Nm3 of biogas per ton of volatile solid digested (Nm3 means ‘normal cubic meter’; for a gas, it means a cubic meter at 20°C and at 1013 mbar).

Characteristics of the biogas

The percentage of CH4 in the produced biogas, and thus the energetic content of the biogas, depends on the type of sludge. Typical percentage is 60 to 65%. As a consequence, the typical energy content of the biogas is between 5.9 and 6.4 kWh/Nm3 of biogas.

Yield for energy production

The yield of the biogas boiler will be considered 85% including losses on the downstream heat circuit.

The yield of the cogeneration engine (or CHP unit) is the ratio between the energy content of the biogas and the energy recovered thanks to specific equipment. It usually ranges:

- between 35 and 45% (according to its size) for electricity production
- between 35 and 50% (according to its size) for heat production

For example, if a quantity of biogas equivalent to 1,000 kWh is burnt in an engine, 350 to 450 kWh of electricity will be produced while 350 to 500 kWh of heat will also be recovered.

3.3.2.5. Enhanced digestion

Enhanced digestion consists in including a thermal hydrolysis stage under pressure upstream the digestion itself. The high temperature and pressure conditions allow to convert the sludge into a more readily biodegradable liquid sludge, thereby significantly increasing the sludge degradation yield in the downstream digesters.

The consequences are:

- Smaller digesters
- Increased production of biogas
- Increased amount of energy
- Reduced amount of digested sludge

3.3.2.6. Co-digestion

Other substrates can be added to the sludge produced by the WWTP into the digester in order to maximize the energy production and to treat organic waste that may be difficult to dispose of by other treatment processes. These substrates can include the following components:

- Sludge from other WWTPs
- Grease from meat processing industries or restaurants
- Kitchen waste
- Dairy by-products (milk, yogurt, etc.)

It is generally necessary to implement a dedicated pretreatment to avoid operational issues in the digester. A screw grinder is usually installed to make sure no large particle enter the digester and the mixture of waste is homogeneous enough.

3.3.2.7. Pre-requisite for sludge digestion implementation

It is recommended to apply the following design considerations before implementing a digestion stage at a WWTP.

The wastewater treatment line should preferably include primary settlers upstream the biological treatment, in order to obtain mixed sludge and not only biological sludge (biological sludge is very poorly degraded during anaerobic digestion).

- Primary treatment usually removes more carbon than nitrogen, thus reducing the C/N ratio of the influent.
- This might imply injection of methanol in the activated sludge tank if the C/N ratio is already low in the raw wastewater and nitrogen removal is targeted; in that case it is not recommended to implement a digestion stage at the WWTP.

If there is no primary settler but only a biological treatment of the wastewater, the sludge digestion stage should preferably be implemented downstream a first stage of sludge hydrolysis in order to enhance the digestion yield which would otherwise be low (only 30% or less for biological sludge only).

Sludge digestion requires the preliminary chemical removal of phosphorous (instead of biological removal) by ferric chloride injection for instance. Otherwise the phosphorous that has been captured by the biological process will be released during the digestion stage and recirculated to the head works.

The dewatering of digested sludge produces a wastewater flow that displays a high ammonium concentration because half of the nitrogen contained in the sludge is released as ammonium during the anaerobic degradation. This return flow will be recirculated to the head works, which has the following consequences:

- Further decrease of the C/N ratio at the inlet of the biological treatment
- Increase of the treatment cost due to the extra load brought by this side stream (Ammonium oxidation requires aeration).

As a conclusion, it is of prime importance to carefully monitor the C/N ratio when a digestion stage is designed and to perform a C and N balance on the whole WWTP.

3.3.3. SLUDGE THICKENING AND DEWATERING AND LIMING

3.3.3.1. Sludge thickening

Sludge treatment usually starts by reducing the water content of the sludge to minimize the final volumes and the transportation costs. Two steps are generally necessary to reach a dryness of approximately 25% to 30 % that facilitates sludge handling and transportation.

The first stage is called thickening and allows to increase the dryness from approximately 1% to 3 - 5%. Sludge thickening can be performed either in static thickeners, where sludge settles at the bottom and water is collected at the top, or in dedicated mechanical equipment called gravity belt-thickeners (Figure 17).

Figure 17 Gravity belt-thickener Flavy, implemented at the Pest-South and Pest-North WWTPs.

3.3.3.2. Sludge dewatering

The traditional alternative to sludge digestion consists in dewatering the sludge to a dryness of 20 to 25 % depending on its final disposal by means of centrifuges. This dewatering stage is preferentially preceded by a thickening stage to increase the final dryness.

3.3.3.3. Sludge liming

Liming consists in mixing lime with the sludge, in order to increase the pH (which allows disinfection and stabilization of the sludge) and in order to increase the dry solid content of the sludge, generally to around 30%, depending on the local regulation. As lime (CaO) combines with the water content of the sludge to precipitate as Ca(OH)2, part of the water is eliminated. Consequently, the volume of limed sludge is slightly smaller than the volume of dewatered sludge, although lime is injected.

Thickening and dewatering and liming sizing

The calculations associated with thickening, dewatering and liming the quantity of sludge currently produced at Chisinau WWTP and the anticipated quantity to be treated in 2020 are presented in Table 29.

Table 29 Calculations for the sludge thickening (with static thickeners), dewatering and liming at Chisinau WWTP (current sludge production in 2010 and expected sludge production in 2020)

		2010	2020
Sludge production			
Daily mass flow	kgSS/d	40 000	62 266
Concentration	g/L	30	8
Daily flow	m³/d	1 333	7 783
Thickening			
Surface load	kgSS/m2/d		50
Number of thickeners	-		6
Area of each thickener	m2		208
Diameter of each thickener	m		16
Concentration of thickened sludge	g/L		35
Daily flow of thickened sludge	m3/d		1 779
Dewatering by centrifugation			
Number of centrifuges (+1 stand-by)		3	3
Number of operational days per week	d/week	5	5
Number of working hours per day	h/d	8	8
Nominal mass flow	kgSS/h	2 333	3 632
Nominal volume flow	m3/h	78	104
Polymer dosing ratio	kg/tSS	8	8
Polymer consumption	kg/week	2 240	3 487
Dryness of dewatered sludge	%	25	25
Flow of dewatered sludge	m3/week	1 120	1 743
Lime addition			
Lime dosing ratio	%	25	25
Consumption of Ca(OH)2	kg/week	70 000	108 966
Density	kg/m3	600	600
Lime consumption	m3/week	117	182
Volume of one silo	m3	60	60
Autonomy with one silo	week	1	0
Number of silos	-	3	3
Autonomy with these silos	week	1,5	1,0

3.3.3.4. Sludge drying

Drying consists in evaporating the water contained in the sludge up to a certain degree of dryness. At 90% dryness, the sludge is stabilized and can be conditioned in bags for example. There are many types of driers, each of them has some specificities. The important parameters for the selection of a technology are: safety, energy consumption, treatment of gases / odors, recovery of the condensates, usual operation mode (24/24 or intermittent) easy start and stop procedures, capacity, etc.

Figure 18 Dried sludge under granulate (left) and pelletized (right) forms

A sludge drier requires thermal energy, around 1 MWh (100 m3 of natural gas) per ton of water to be evaporated for the standard technologies. It will be considered that the heat is produced by combustion of natural gas in a boiler, or directly in the drier.

It is highly recommended to dewater the sludge before drying it in order to spend less fuel (natural gas) to dry the dewatered sludge.

Some driers deliver sludge granulates as a final product (Figure 18). They can be used in agriculture. Granulates are easy to condition, store, transport and spread in the fields. The required storage capacity is also reduced because the volume of dried sludge is lower compared to dewatered or limed sludge.

3.3.4. OVERVIEW OF POSSIBLE FINAL DISPOSAL ROUTES

Wastewater treatment shall not be envisaged without thinking about the way of handling the sludge that is produced during the wastewater treatment process. The following features should be investigated when setting up sludge management plans.

- The quantity and the quality of the sludge, which differ depending on the processes implemented at the WWTP.
- The local regulatory framework related to sludge management and disposal.
- The possibilities of considering sludge as a product and not only as a waste, through adapted treatment and/or monitoring procedures.

The Moldovan regulation related to waste management and sludge in particular is poor while it is non-existing when sludge valorization as a product is concerned. It was therefore decided to apply the EU regulation when appropriate.

The main final sludge disposal routes, as can be experienced worldwide, are presented in Figure 19 and further detailed in the following sections.

Final sludge disposal appears to be an issue in Chisinau where no sustainable solution has yet been identified. The most common final disposal options are presented below with a preliminary assessment of their respective technical feasibility and some financial elements.

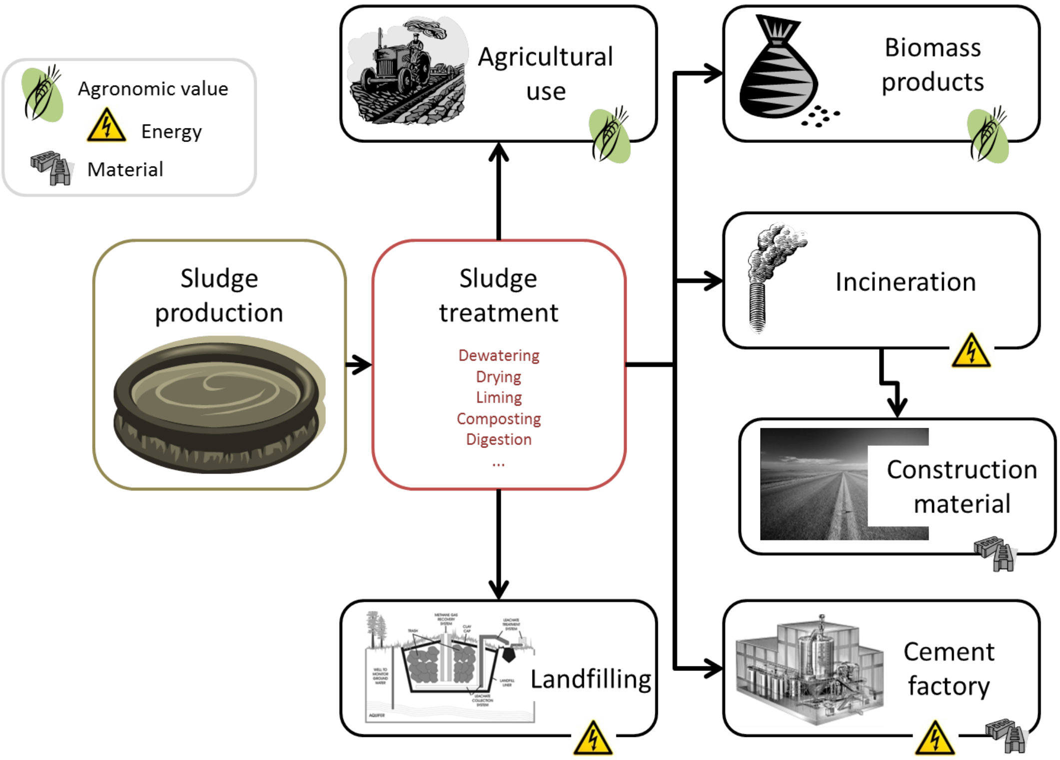


Figure 19 Final sludge disposal routes

3.3.5. LANDFILLING

3.3.5.1. Applicable regulation

The Moldovan regulation regarding waste or sludge landfilling is reported to be not compliant with the EU regulation (Table 30).

Table 30 Moldovan law on the landfilling of waste (extracted from: Environmental protection law and policy, Law approximation to EU standards in the Republic of Moldova, Breda Howard, Ludmila Gofman, August 2010)

EU legislation (see Chapter 4)	Legal transposition degree of Republic of Moldova National laws / by-laws / drafts (covering the area of the relevant EU act)	Necessary legislative measures	Timetable 2010-2015 (see Chapter 6 and Annex 4A)	Comments and recommendations for future steps in order to achieve full approximation
	The Compatibility Declaration issued by CLA in September 2009 stated that the law is partially compatible with the Directive's requirements. The revised Draft Law on waste is ready to be submitted to the CLA by the end of July 2010. The CLA Compatibility Declaration for the draft EPL dated 15.07.2010 states that the draft is partially compatible with the Directive's requirements.			
Directive 1999/31/EC on the landfill of waste as amended by Regulation (EC) 1882/2003 The following provisions shall be applicable: • adoption of national legislation and designation of competent authority/ies • classification of landfill sites (Art. 4) • preparation of a national strategy reducing the amount of biodegradable municipal waste going to landfill (Art. 5) • establishment of an application and permit system and of waste acceptance procedures (Art. 5-7, 11, 12 and 14) • establishment of control and monitoring procedures in the operation phase of landfills and of closure and after-care procedures for landfills to be disaffected (Art. 12 and 13) • establishment of conditioning plans for existing landfill sites (Art. 14) • establishment of a costing mechanism (Art. 10) • ensuring the relevant waste is subject to treatment before landfilling (Art. 6)	NOT COMPATIBLE WITH EU EQUIREMENTS The relevant national legislation includes: • Law on Production Waste and Household Waste No. 1347 of 09 October 1997 • Law on environmental protection No.1515 of 16 June 1993. A preliminary assessment indicates that the legislation is not compatible with the EU Directive's requirements.	Development of necessary legislation measures in compliant with Directive 1999/31/EC	2014	There are close legislative links between this Directive and the Waste Framework Directive. Directive 1999/31/EC places substantial restrictions on the way in which landfills may be used for the disposal of waste, including technical conditions for their design and operation as well as monitoring and closure, and restrictions on the types of wastes that may be landfilled. The administrative systems for achieving this will be established through the institutions that are required to be set up under the Waste Framework Directive (2006/12/EC).

Environmental protection law and policy
Law approximation to EU standards in the Republic of Moldova
Breda Howard
Ludmila Gofman,
August 2010

It is proposed to apply the EU legislation as presented in Article 14 of the Council Directive 91/271/EEC concerning urban waste-water treatment which was adopted on May 21st 1991 (Table 31).

Table 31 Article 14 of 91/271/EEC related to sludge management

Article 14 1. Sludge arising from waste water treatment shall be re-used whenever appropriate. Disposal routes shall minimize the adverse effects on the environment. 2. Competent authorities or appropriate bodies shall ensure that before 31 December 1998 the disposal of sludge from urban waste water treatment plants is subject to general rules or registration or authorization. 3. Member States shall ensure that by 31 December 1998 the disposal of sludge to surface waters by dumping from ships, by discharge from pipelines or by other means is phased out. 4. Until the elimination of the forms of disposal mentioned in paragraph 3, Member States shall ensure that the total amount of toxic, persistent or bioaccumulable materials in sludge disposed of to surface waters is licensed for disposal and progressively reduced.

This article does not describe any specific conditions for sludge landfilling. Several EU member states have therefore set out a more restrictive regulation that generally includes the following conditions:

- Traceability (no mixing of sludge of different origins)
- No contamination with hazardous waste (heavy metals, radioactive or infectious material, etc.)
- Conditions of monitoring (sampling, visual inspection, etc.)
- Dry solid content above 30%

It is recommended to apply these conditions for sludge landfilling in Chisinau.

3.3.5.2. Terms of reference

The terms of reference specifically describe the scope of work with regards to landfill site investigations (Table 32).

Table 32 Extract of the Terms of reference

If no adequate site for the deposit can be found on the municipal landfill potential external sites shall be identified and assessed. Preliminary investigation into availability, ownership and prices of land (real estate) for potential landfill sites, realistic time estimates for procurement/expropriation in view of prevailing legal and administrative procedures.

3.3.5.1. Brief description of a landfill site

There are different types of landfill sites that are designed to store wastes with various environmental risk potentials. It is not usual practice to design a landfill for municipal sludge only, since the volume of sludge produced by a community is generally low compared to the production of other solid waste. Domestic sludge is therefore usually disposed of in landfill sites together with municipal solid waste and other wastes that display a low environmental risk when stored in appropriate conditions. Separate cells within the landfill site may however be dedicated to host domestic sludge only.

Figure 20 Example of a landfill site for sludge and domestic waste (Claye-Souilly, France)

The landfill must be carefully design to minimize its environmental impact:

- Containment of the landfilled wastes in several independent and closed cells (the waste is not in direct contact with the surrounding soil thanks to the implementation of impervious surface material such as clay and geotextile, Figure 21 and Figure 22)
- Collection of water flows (Figure 23) and treatment of leachates
- Collection of biogas and burning in flares or further gas treatment for energy recovery (Figure 24)

Visual integration (landfill sites are generally partially or totally buried, sometimes in existing structures like old quarries, see Figure 25)

The life span of a landfill is generally between 20 and 30 years. Once the landfill is full it is covered and revegetalized and monitored for the next 30 years.

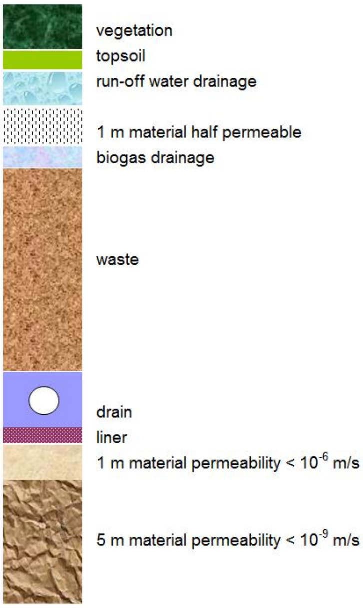


Figure 21 Schematic cross section of a landfill cell

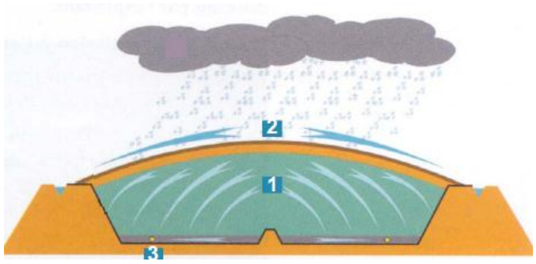


Figure 22 View of a landfill cell during the construction phase; note the drains and the geotextile.

Figure 23 Hydrological elements of a landfill cell: 1- leachate collection, 2- surface runoff collection, 3- drainage of groundwater infiltration

Figure 24 Biogas collection pipes and flaring system at SERAF landfill (France)

Figure 25 Example of a landfill located in an ancient quarry (Espira de l'Agly, France)

3.3.5.2. Technical specifications

The technical specifications of potential landfill sites derive from the characteristics and the volume of the material to be landfilled and the fulfillment of the objectives presented below.

Material to be landfilled

- Dewatered and stabilized sludge from the WWTP
- Characteristics: DS content > 30%
- Volume to be landfilled: approximately 150 m3/d or 1,000,000 m3 for a 20-year period (40 tDS/d in 2010, which equals 130 m3/d at a 30% DS content + other sludge of various origins to be landfilled)
- Typical depth: 12 m
- Surface required for a life span of 20 years: 10 ha

Objectives

- Objective 1: minimize the sludge transport cost (the landfill site should be as close to Chisinau WWTP as possible, existing road access is preferred)
- Objective 2: minimize nuisances for the neighbourhood (the landfill site should not be too close to dwelling areas, i.e. further than 200 m away is preferred))
- Objective 3: minimize the environmental impact (the geology/hydrogeology - no leak to the aquifer – of the site should be favourable, it should not be located within an area subject to flooding, and should not be located in an environmentally sensitive area)

3.3.5.3. Proposed location for a sludge landfill site

A potential landfill site has been identified near Cobusca Veche. It is located approximated 30 km far from Chisinau WWTP (Figure 26). An aerial view of the land which could be used to host the sludge landfill site is presented in Figure 27. Further details can be found in Section 12. The owner of the land is the Local Public Administration of Tintareni commune which is not opposed to selling this land, although the decision must be approved by the municipal council. The public procurement procedure can take 2 to 3 months.

The positive features of this land are:

- The vicinity with M1 national road (concrete road)
- The relative long distance from populated localities
- The Local Public Administration's consent to negotiate the sale of the land
- The existence of the clay layer near the surface (further studies of its depth and thickness are required)

The existence of some forest areas near the proposed site could also allow to implement demonstration plots for which the sludge can be used as fertilizer.

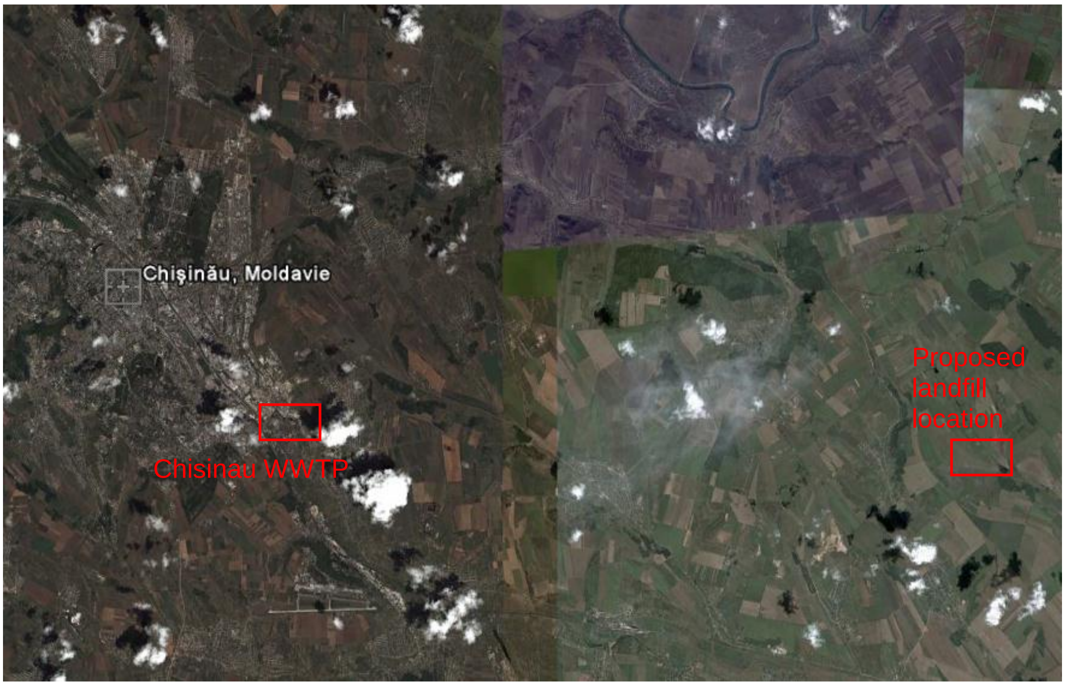


Figure 26 Proposed location of the sludge landfill site

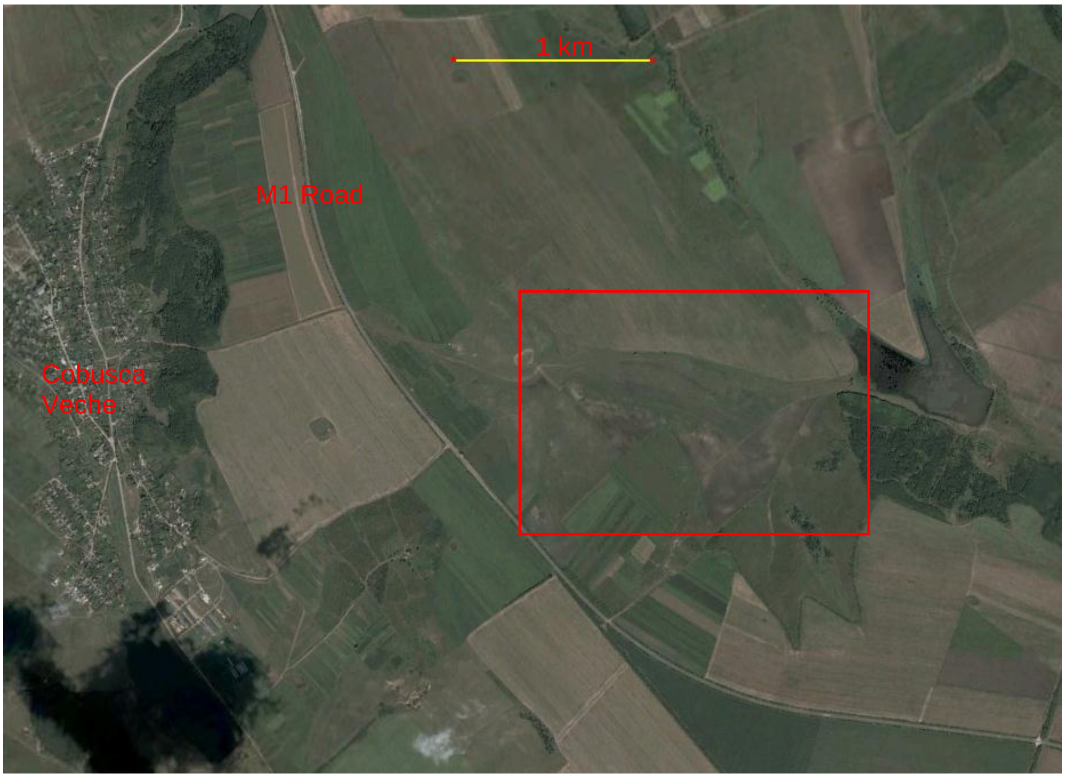


Figure 27 Proposed location of the sludge landfill site (red square)

3.3.5.4. Financial elements

CAPEX

The investment costs include the following elements:

- Land procurement (2,000 €/ha): 20 k€
- Excavation works and site landscaping and fencing: 5,000 k€
- Drainage of leachate (no treatment in the first development phase): 250 k€
- Biogas collection and flaring: 250 k€

The CAPEX is estimated at 5,500 k€.

OPEX

The operation costs include the following items:

- waste handling and compacting in the cells
- operation and maintenance of the leachate and biogas collection system
- monitoring process
- site security watch

It is estimated that 5 full-time workers are needed to fulfill these tasks.

The OPEX is estimated at 50 k€/year.

3.3.6. USE IN CEMENT FACTORY

3.3.6.1. Applicable regulation

No specific regulation addresses the use of sludge in cement factories in Moldova whereas the EU Directive 2000/76/EC put special provisions for cement kilns co-incinerating waste (limit values for air emission in terms of NOx, SO2 and other compounds).

Local agreements are also generally set up between the cement companies and the water companies when both parties are interested in this option, especially regarding the minimum low calorific value of the sludge.

3.3.6.2. Technical feasibility

The only cement factory in Moldova is the Lafarge factory located in Rezina, about 80 km North of Chisinau. The factory manager provided most of the information presented below.

The quarry which supplies the cement factory is located nearby and it is expected that the operation of the quarry can last at least 50 more years.

The road from Chisinau WWTP to Rezina is in very bad condition, especially in spring during the thaw period.

The operation of the cement factory is intermittent and follows the activity of the construction sector, which is much less active in winter due to the weather conditions, and which was significantly affected by the financial crisis of the past couple of years. The cement factory was in operation about 45% of the time in 2011 (approximately 5 months over the whole year) and production periods were concentrated in summer. Before the crisis the operation rate was around 70 %.

The cement factory received the permit to incinerate used tyres in 2011 and will need to apply for a permit to burn sludge in the future if this option is implemented. The delivery of such a permit should not be an issue providing flue gas treatment is adequate, which may require upgrade works.

The technical specifications for the sludge that can be incinerated include the following:

- Minimum dryness: 90%
- Lower calorific value (LCV): 3,500 kcal/kg

The maximum sludge mass flow rate that can be incinerated in the cement factory is 3 t/h which corresponds to 2.7 tDS/h or 65 tDS/d for a 24h/d operation. This is higher than the sludge production of Chisinau WWTP (~40 tDS/d) so the burning capacity of the cement factory is high enough to treat the sludge produced at Chisinau WWTP.

The minimum sludge dryness of 90% imposes the preliminary drying of the sludge. This is traditionally achieved through thermal drying, which is an energy intensive process. Thermal drying can be coupled to the cement kilns - which would require an additional investment of approximately 2,000 k€ but almost no energy cost since the heat would be taken from the cement kilns for free - or be performed at the WWTP for an investment cost of 1,800 k€. The latter solution would significantly reduce the volume of sludge to be transported and the associated transportation cost and would finally be more beneficial in terms of OPEX, as presented by the following calculations (Table 33).

List of assumptions:

- Distance WWTP – cement factory: 80 km
- Transportation cost: 20 MDL/(t.km)
- Electricity cost: 1,34 MDL/kWh

- Weight of sludge after dewatering (dryness: 25%): 38 tDS/d / 0.25 = 152 t/d
- Weight of sludge after drying (dryness: 90%): 38 tDS/d / 0.90 = 42 t/d

Table 33 OPEX comparison of sludge drying at the WWTP or at the cement factory (in MDL/d)

	Drying at the WWTP	Drying at the cement factory
Transportation cost	67,200	243,200
Energy cost	23,900	0
Total	91,100	243,200

The solution consisting in drying the sludge at the WWTP is all the most preferred since Lafarge does not seem to be very interested and enthusiastic in coupling sludge thermal drying to the existing cement kilns.

3.3.6.3. Financial elements

CAPEX

Adaptation of the cement kilns and associated works: 1.5 million €

Improvement of the flue gas treatment at the cement factory: 4 million €

Thermal drier at the WWTP: 1.8 million €

The CAPEX is estimated at 7,300 k€.

OPEX

Energy cost for thermal drying: 550 k€/year

Transportation cost: 1,500 k€/year

Incineration cost in cement kilns: 20 €/t of wet sludge, i.e. 300 k€/year

The OPEX is estimated at 2,850 k€/year.

3.3.7. INCINERATION

3.3.7.1. Warning

The word “incineration” is used worldwide to designate the controlled process of burning waste, sludge or other material in a dedicated facility. It appears that many Moldovans are not aware of this definition and use “incineration” as a direct translation from the Russian word meaning “burning”, which may lead to confusion and misunderstanding. For instance it is common in Moldova to burn solid wastes in open spaces and without any control, this action being referred as “incineration” by many Moldovans whereas it significantly differs from the definition given above.

3.3.7.2. Applicable regulation

As stated by Howard and Gofman in 2010, there is no comparable law in Moldova national laws to the EU legislation that rules the incineration of waste as presented in the Directive 2000/76/EC (Table 34). This Directive covers incineration and co-incineration plants and sets limit values for air emission and for discharges of waste water from the cleaning of exhaust gases, among other things.

Table 34 Moldovan law on the incineration of waste (extracted from: Environmental protection law and policy, Law approximation to EU standards in the Republic of Moldova, Breda Howard, Ludmila Gofman, August 2010)

EU legislation **(see Chapter 4)**	**Legal transposition degree of Republic of Moldova National laws / by-laws / drafts (covering the area of the relevant EU act)**	**Necessary legislative measures**	**Timetable 2010-2015 (see Chapter 6 and Annex 4A)**	**Comments and recommendations for future steps in order to achieve full approximation**
Directive 2000/76/EC on the incineration of waste	**NO COMPARABLE LAW IN MOLDOVA NATIONAL LAWS** The relevant legal acts includes: • Law on Production Waste and Household Waste No. 1347 of 09 October 1997 • Law on environmental protection No.1515 of 16 June 1993. A preliminary assessment indicates that the legislation is not compatible with the EU Directive. The draft Law on waste states that waste incineration is permitted only in authorised for that purpose facilities. According to the Compatibility Statement issued on 30 September 2009 by CLA for the draft Law on waste, the Art. 61 (Art. 60 in the current draft of the law on waste) is partially compatible with the Directive's provisions. The draft Regulations on waste incineration is being developed by the Ministry for Environment. The draft Regulations on waste incineration, currently under preparation, intends to approximate the national legislation to the requirements of Directive 2000/76/EC on the incineration of waste.	Complete drafting draft Regulations on waste incineration in compliance with Directive 2000/76/EC	**2013**[438]	The Waste Incineration Directive was adopted on the basis of Article 175 (1) of the EC Treaty. This means that Member States are not excluded from setting or maintaining rules that are stricter than those in the directive, provided that such measures are otherwise compatible with the EU Treaty. The Waste Incineration Directive is a so-called minimum harmonisation directive. Planning for transposition of Directive 2000/76/EC should take also account of the provisions of the new Industrial Emissions Directive (IED) which recasts the WID.

3.3.7.3. Incineration

The major interest of thermal oxidation is the ability to produce energy thanks to the sludge energy potential. A rough estimate of the sludge production gives a value in the range of 40 to 80 g/L of dry solid per day and per capita, containing 2/3 of organics or more. Consequently, the energy potential on a dry fuel basis achieves 10 to 15 W per capita.

A huge amount of energy is recoverable through thermal oxidation processes. Practically, this energy, at high enthalpy level, is recovered on the economizer. The recovering fluid can be pressurized water, steam or diathermy oil (or air if energy is wasted). The heat can be directly used as thermal fluid for building heating, process requirements, or preheating of sludge prior to dewatering/pre-drying to improve the performances.

The best way to value the energy potential is definitely a cogeneration facility through the generation of high pressure steam and turbine with steam extraction (Rankine Cycle). In such a way, up to 35% of the sludge potential energy can be recovered as heat and 10% as electricity. The implementation of a cogeneration facility is therefore very beneficial for the environment since it reduces the fossil energy utilization and the associated emission of greenhouse gases.

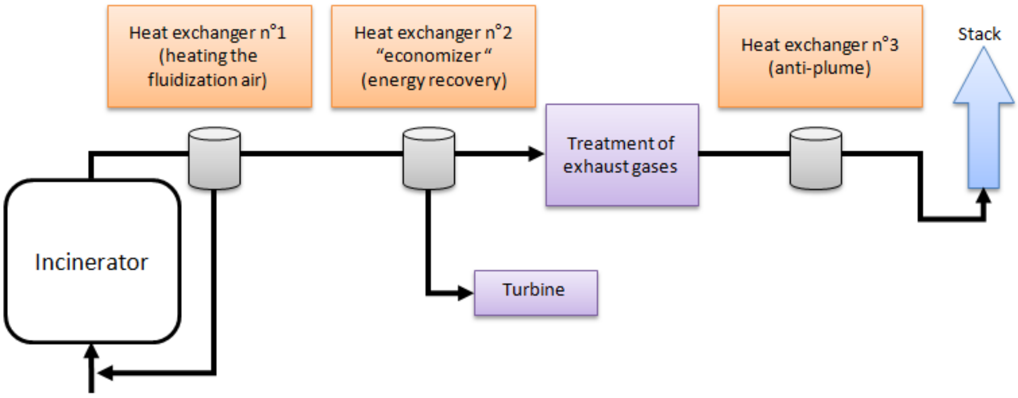


Figure 28: Scheme of energy transfers in an incinerator

3.3.7.4. Common incineration plant with municipal solid waste (co-incineration) – existing project

The project consisting in the design and build of a solid waste incineration plant in Chisinau has been discussed for many years. There is a project of building an incinerator for solid waste on the land currently occupied by sludge beds. The decision has been approved by the Municipality. This incineration plant originally included the processing of the sludge of Chisinau WWTP, thus making this plant a co-incineration plant (incineration of both solid waste and sludge). However and despite recent decisions taken by the Municipality of Chisinau (see below), no detailed design study is available and no construction work has started yet, which tends to indicate that this project may fail like many others due to the lack of investment and/or cost recovery capabilities, although the relevance of this project is high.

The decision 8/5 of Chisinau Municipal Council dated 15/09/2009 approved the contract to design and build an incineration plant for solid waste between Chisinau Municipality and the Italian company STR Engineering Consulting and indicates that the Contractor shall assess the feasibility of including the thermal valorisation of the sludge produced by Chisinau WWTP into the project.

The decision 3/20 of Chisinau Municipal Council dated 23/03/2010 displays the details related to the attribution of a piece of land to the incineration project in the vicinity of Chisinau WWTP.

The available technical documentation related to this project consists only in a very general description of a conventional incineration treatment plant with very few references to the specific Chisinau project. The only design criteria that are mentioned in this document refer to a processing capacity of 500 t/d of waste (Figure 29) while no reference to sludge incineration is made.

Instalație de exploatare termică.

Pentru RSU și derivatele: (RSAU-CDR).

Octombrie anul 2005.

Evaluator termic cu cuptor cu grilă mobilă pentru RSU și derivate.

Date generale.

Instalația de Evaluator termic propus funcționează pe două linii independente, fiecare din ele poate prelucra 500 tone pe zi de deșeuri cu o capacitate prevăzută de restituire a căldurii de la 7500 la 1500 kilojouli / kg. Deșeurile prelucrate sunt constituite din deșeuri solide urbane (RSU) și deșeuri speciale nepericuloase asimilabile urbane; instalația este în stare să prelucreze chiar și deșeuri spitalicești și resturi biologice de origine urbană. O turbină care utilizează vapori de 430 grade Celsius și 62 bari produs de cazane, permite de a recupera energie cu ....MW de putere electrică instalată.

Figure 29 Extract from the description of the incineration project as provided by STR Consulting Engineering in 2005.

Due to the lack of project description emanating from both the Contractor (STR Engineering Consulting SRL) and the Employer (Chisinau Municipality), a technical and financial assessment of the project has been imagined by the UN (see Section 11 for more information). This assessment did not mention the fact that the plant was not only intended to burn municipal solid waste but also municipal sludge as presented by the decision of Chisinau Municipal Council.

This assessment reported the following figures for such an incineration plant:

- CAPEX: 200,000 k€
- OPEX: 15,000 k€/year

In case the incineration of sludge was not included in the scope of these financial estimates, some additional budget must be dedicated to the implementation of a sludge injection system into the furnace, which could cost approximately 500 k€.

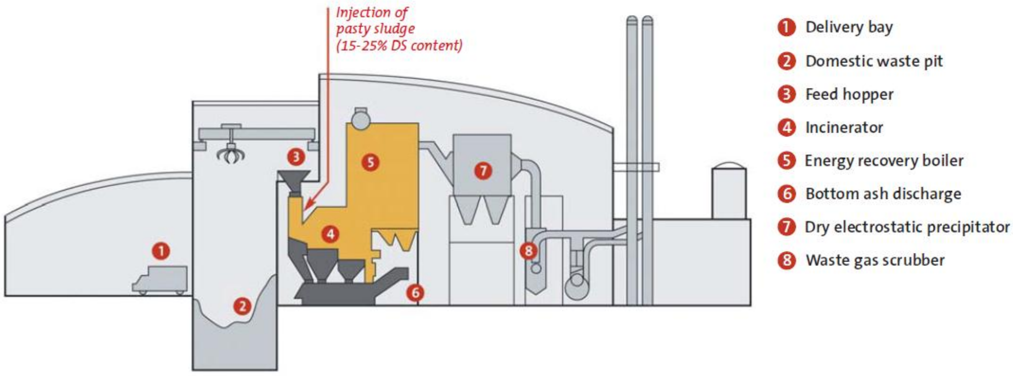


Figure 30 Scheme of a solid waste incinerator with additional injection of sludge

3.3.7.5. Standalone incineration

Another option for sludge incineration consists in incinerated the sludge in a dedicated facility that is specially designed to handle the quantity of sludge produced by Chisinau WWTP and its very characteristics.

Process description

Incineration is a thermal process that burns the sludge. Today, the most commonly used technology is the “fluidized bed furnace” (FBF). FBF are based on the principle of fluidizing a bed of sand with hot air heated from the bottom. This technology results in the total combustion of the sludge at a temperature between 850 – 900 °C in the span of only a few seconds of retention time.

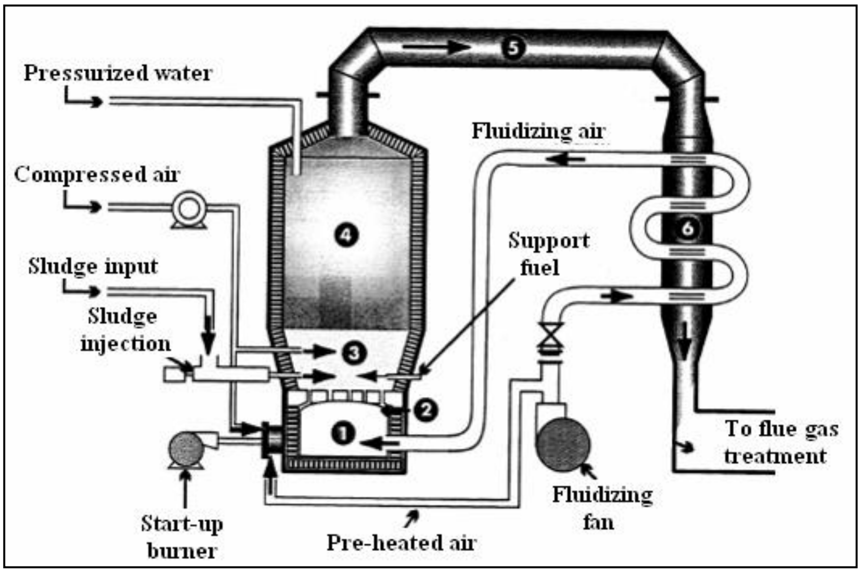


Figure 31 Scheme of a fluidized bed furnace

A fluidized bed incinerator is composed of a four-part reactor:

- A fluidizing air intake area, the wind box (1). Fluidizing air, which serves as combustion air, goes into the wind box, either at room temperature (cold wind box) or pre-heated to about 600°C (hot wind box). Most fluidized bed sludge incinerators are designed with hot wind boxes
- An air distribution system (2)
- A sand bed fluidized at around 750°C, into which the sludge is injected, with or without support fuel (3)

- A combustion chamber on the upper level (4)

Fluidized bed incinerators are not very flexible when it comes to variations in sludge inlet flow rate, at a constant heat balance (flexibility of about 15% with respect to the nominal load). On the other hand, it can handle frequent stops and starts.

The heat required to evaporate the water and bring the combustion gases to the desired temperature is brought by:

- the oxidation of the organic content in the sludge
- the re-heating of the combustion air to about 600°C (hot wind box)
- the use of support fuel, if needed (natural gas, fuel oil)

The sludge is completely destroyed by combustion, leaving the following three by-products:

- Ash or non-hazardous residues: composed of the mineral content of the sludge, which is recovered at the incinerator outlet. The quantity of ash produced depends on the sludge's initial mineral content. The ash is usually removed to a landfill center or could be recycled for use in cement production or road construction.
- Exhaust gas residue or hazardous residue: composed of the pollutants contained in the sludge, which have been trapped during the treatment of combustion gas, mainly heavy metals and acids. The quantity is estimated at 20-40 kg/tDS for dry treatment and much less for wet treatment. The residue is removed to a specific sanitary landfill.
- Combustion gases: dispersed into the atmosphere after energy recovery (at the cooling stage) and treatment. Thermal energy is recovered from the exhaust gas.

There are strict regulations governing the discharge of incineration gases into the atmosphere (for example in the European Union: Directive EU 2000/76/CEE). The directive requires the exhaust gas to undergo specific treatment.

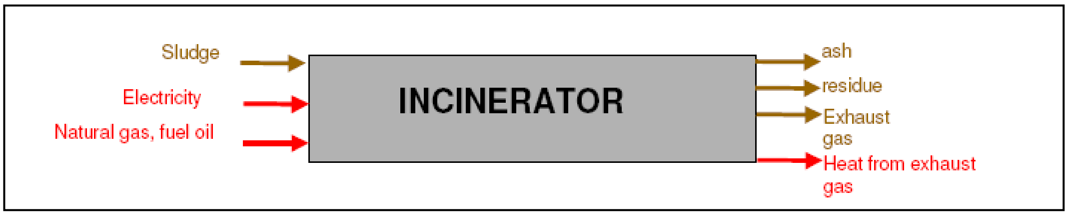


Figure 32 Input and output of an incinerator

Technical feasibility

The residues of sludge incineration and flue gas treatment consists in ashes that can be further utilized as mineral material in cement factory or concrete manufacturing process or used as building material for road construction. Ultimately, ashes can also be landfilled.

Anyway it is recommended to plan for an alternative treatment disposal option in order to cope with the long maintenance periods of the furnaces which last abound 15 days per year. During these periods the dewatered sludge will preferably be limed and transferred to a landfill or stored on site if storage capacity is available.

Financial elements

CAPEX

Thermal drier at the WWTP (to reach 35% dryness): 400 k€

Incinerator: 12,600 k€

The CAPEX is estimated at 13,000 k€.

OPEX

Energy cost for thermal drying: 0 k€/year (thermal self-sufficiency is achieved)

Transportation cost of ash and solid residues (11 t/d) to a landfill: 150 k€/year

Dedicated O&M staff (6 people): 20 k€/year

Miscellaneous (analytical measurements, maintenance works, etc.): 30 k€/year

The OPEX is estimated at 200 k€/year.

3.3.8. AGRICULTURAL USE

3.3.8.1. Moldovan context

Moldova is a rural country where agricultural lands are homogeneously spread all over the country.

After the collapse of the USSR, the kolkhozes were dismantled and the land was distributed to many land owners. Today the organization of the agricultural sector is the following:

- One main employer rents and cultivates the parcels of several land owners to constitute an area of approx. 100 ha.
- The average area of the land owned by one person is about 4 ha. Each land owner can decide the way his own land is fertilized and cultivated (therefore he decides whether some sludge or some fertilizer can be spread out over his land). He can also choose to work for the main employer – in that case he gets a salary for his job – or only to give the right to cultivate his land to the employer in exchange of goods as rental.

Fertilizers are usually used, although the quantities of fertilizers have significantly decreased since the soviet era due to the fact that farmers are no longer able to pay for the purchase of fertilizers.

Although the use of sludge as a fertilizer can be beneficial in many ways to the farmers, a great effort would be necessary to convince the farmers to do so. The reluctance of farmers to use sludge as a fertilizer originates from a lack of knowledge about the very nature of the sludge and from the general feeling among the population which considers sludge as a dirty waste that presents unknown health hazards.

It must therefore be emphasized that agricultural use of sludge in Moldova is more depending on the land owner’s acceptance rather than on the technical feasibility of this disposal option.

3.3.8.2. Applicable regulation

The current applicable regulation about land spreading of sludge from WWTPs in Moldova is included in the document called “Hotarîre cu privire la aprobarea Reglementarii tehnice “Masurile de protectie a solului în cadrul practicilor agricole” nr. 1157 din 13.10.2008”. Although this document addresses general issues about soil protection measures, Section 11 is specifically dedicated to the conditions of sludge spreading on agricultural lands and states the following:

- Sludge can be used in agriculture
- Maximum values are given for trace metals in appendices to the regulation.
- Time windows for sludge spreading are provided depending on the crop

- Sludge spreading shall not degrade the nature of soils, nor the quality of surface water and groundwater.
- The quality of soils and sludge shall be monitored with methods provided in appendices to the regulation.

3.3.8.3. Technical feasibility

The requirements of agricultural land in terms of nitrogen and phosphorus are usually met with domestic sludge at a dosing rate of around 30 tDS/ha every 10 years (i.e. 3 tDS/(ha.y). This ratio is an estimation only and should be confirmed by an agricultural study. The spreading is performed every 4 years on every field depending on the type of culture, the quality of the sludge, etc.

A sludge production of 40 tDS/d will then require approximately 5,000 ha of agricultural land.

However, this dosing rate should be checked against the regulation about maximum cumulated loads of heavy metal over a 10 year period as presented in Table 35. This table is based on the Moldovan regulation (Hotarîre cu privire la aprobarea Reglementarii tehnice "Masurile de protectie a solului în cadrul practicilor agricole" nr. 1157 din 13.10.2008) and on the French regulation (Arrêté du 8 janvier 1998 relatif à l'épandage des boues issues du traitement des eaux usees). The concentrations of heavy metal in sludge are taken from a report entitled "Aviz privind pretabilitatea namolurilor Statiei de epurare Chisinau pentru utilizare in agricultura, Centrul republican de pedologie aplicata, 22/03/2010".

Table 35 Limit values and maximum cumulated load for heavy metals contained in sludge spread onto agricultural lands, together with actual concentration values and associated minimum land area.

	Masurile de protectie a solului…		Arrêté du 8 janvier 1998 (France)		*WWTP sludge*	Minimum area required
	Limit value mg/kgDS	Max. flow (10 year average) mg/kgDS?/year	Limit value mg/kgDS	Max. flow (10 year cumulated) g/m2	*Average concentration mg/kgDS*	(according to French limits) ha
Cd	40	0.15	10	0.015	*32*	31147
Cu	1750	12	1000	1.5	*150*	1460
Ni	400	3	200	0.3	*100*	4867
Pb	1200	15	800	1.5	*330*	3212
Zn	4000	30	3000	4.5	*400*	1298
Hg	25	0.1	10	0.015	*NA*	NA
Cr	-	-	1000	1.5	*400*	3893
Cr+Cu+Ni+Zn			4000	6	*1050*	2555
Organic micropollutants	No		Yes			

This table suggests that - following the French regulation on heavy metals since the Moldovan regulation features some missing data - the minimum area required over a ten year period is below 5,000 ha for all heavy metals except cadmium which requires an area of more than 30,000 ha. The latter result is doubtful since other measurements performed by ACC in 2009 and in 2010 over various sludge samples at Chisinau WWTP showed that cadmium concentration was below the detection limit (<10 mg/kg) in the sludge produced at Chisinau WWTP ("Fisa rezultatelor fizico-chimice effectuate asupra namolului uscat de la platformele de namol sese, conform hotaririi guvernului nr. 1157 din 13/10/2009, ACC 29/03/2010").

Therefore it can be concluded that:

1) Sludge content is compatible with agricultural use as per the Moldovan Technical Regulation "Masurile de protective a solului in cadrul practicilor agricole". The heavy metals content of sludge do not put any constraint on its spreading over agricultural land, which is the opinion of the Republican Centre of applied pedology expressed in the afore mentioned report dated 22/03/2010, and which is also in accordance with the fact that heavy industrial polluters do no longer exist within the Chisinau area.
2) The land area required to spread the sludge produced at Chisinau WWTP is approximately 5,000 ha.

Besides, it should be noted that a large storage unit must be constructed, for the sludge must usually be stored prior to spreading because the fields require fertilizers only twice a year at most. If the storage capacity required is considered to be around 60 % of the yearly production of sludge (half a year + 20 % margin) then a storage capacity of approximately 35,000 m3 must be constructed. This represents a surface area of more than 1 ha. If the sludge is not well stabilized, odour could be an issue.

It is also important to plan the practical implementation of sludge transportation and land spreading and the limit of responsibilities between ACC, the farmers and any other third party that could be in charge of the transport and of the spreading of the sludge from Chisinau WWTP directly to the fields. A large fleet of trucks and tractors fitted with specific equipment (Figure 33) will be required.

Figure 33 Equipment for sludge spreading on agricultural land

Nonetheless, agriculture use of sludge (limed or dried or digested) displays the following main advantages:

- Very low CAPEX (not included sludge storage facility)
- Very simple operation (excluding transportation)
- Use of the sludge and reduction of the consumption of fertilizers

3.3.8.4. Financial elements

CAPEX

Cost of sludge storage (covered building without odor treatment): 1,500 k€

Liming facility: 250 k€

The CAPEX is estimated at 1,750 k€ (fleet of trucks and tractors is not included).

OPEX

Transportation cost of sludge: 1,400 k€/year

Cost of lime: 200 k€/year

The OPEX is estimated at 1,600 k€/year.

3.3.9. SHORT ROTATION COPPICE

3.3.9.1. Technical feasibility

An alternative to sludge spreading over agricultural land consists in spreading the sludge on a specific land where short rotation coppice is grown (Figure 34). This alternative has the following advantages over agricultural land spreading:

1) The site is generally closed to the public, which significantly reduces the health and safety issues that can arise when people can get in direct contact with an insufficiently disinfected sludge.

2) The short rotation coppice allows for the production of biomass that can be used as energy source in a wood boiler, thus producing additional revenue for the operator. This advantage may not be relevant in case farmers pay for the sludge they spread on their agricultural land.

3) The operator of the plant and of the sludge treatment line can also be the operator of the short rotation coppice, thus ensuring a smooth and consistent operation of the whole sludge treatment and disposal system.

4) Public acceptance of sludge spreading on agricultural land does not need to be gained.

However this alternative requires the following elements:

- The same available land area – approximately 5,000 ha – as for agricultural land spreading. This large area may not be available around Chisinau to plant short rotation coppice.
- An existing power plant which utilizes biomass as fuel, so that the energy content of the wood chips can be recovered. Such a power plant is not known to be pre-existing in or around Chisinau.

Figure 34 Harvesting of short rotation coppice for biomass production

3.3.9.2. Financial elements

OPEX and CAPEX estimates of this final sludge disposal option are very similar to the ones presented above for the conventional agricultural use.

3.3.10. Sludge composting

Sludge composting is an alternative to the direct use of sludge in agriculture. Composting implies mixing sludge with more structuring material such as wood chips or residues of gardening before the composting process itself which allows for the dry aerobic degradation of the organic matter and the hygienisation of the composted material.

Composting is economically relevant as soon as the final composted product is recognized as a valuable product which can be certified and sold at a price that allows to cover part of the relatively high CAPEX and OPEX associated with this process. These conditions are not met in the local context of Moldova and it appears premature to further investigate the feasibility of this option since agricultural use of the sludge itself is not yet ensured and common practice in Moldova.

3.3.11. COMPARISONS OF FINAL SLUDGE DISPOSAL OPTIONS

3.3.11.1. Financial comparison

Five alternatives for final sludge disposal options have been compared in terms of CAPEX and OPEX (cumulated over a 20 year period without any kind of financial adjustment). The results are plotted in Figure 35 and show that – considering the hypotheses made to do this evaluation – incineration at Chisinau WWTP and agricultural use are the most economical options.

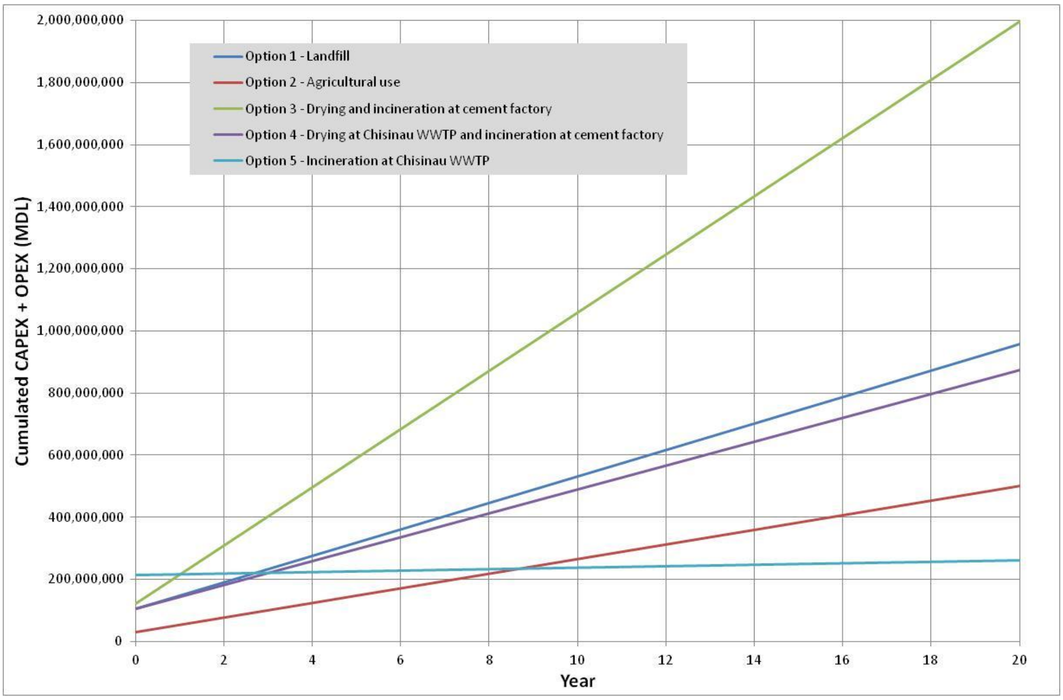


Figure 35 Estimated evolution of the cumulated CAPEX and OPEX for various final sludge disposal options (downstream sludge dewatering)

3.3.11.2. Relevance of mixing final sludge disposal options

Whatever the final sludge disposal option that will be selected, it is believed that having more than one final sludge disposal route ready to use is a sensible strategy which would limit the risks in case of temporary or permanent failure of the selected option (regulation issue in case of agricultural use or incineration, political decision originating from complaints of the neighborhood, shutdown of the cement factory, etc.). A few examples of mixing strategies are described in Table 36.

Table 36 Relevance of mixing final sludge disposal options

How?	Pros	Cons
Co-treatment of sludge with solid waste		
This can be done either in an incineration plant (co-incineration) or in a common landfill where sludge is disposed of with municipal	CAPEX and OPEX reduction when designed simultaneously for sludge and solid waste (scale effect)	ACC would not be the only stakeholder and the project implementation may be delayed due to the studies required on the

solid waste.		side of solid waste management.
Cement factory and another option		
Sludge valorization in a cement factory cannot be envisaged as the only final disposal option since the operation of the cement factory is intermittent. This must be combined with another disposal option such as landfilling or valorization of dried sludge pellets in agriculture for instance.	Some flexibility in the sludge management system is introduced by the possibility to shift from one option to the other when necessary, or in case of failure of one option.	At least two final disposal options must be available, which increases the CAPEX, OPEX and administrative work of the whole sludge management system.
Incineration plant and landfill		
Future sludge quantity and quality are difficult to precisely anticipate and the incineration plant may be built before the implementation of the full renewal of Chisinau WWTP. Consequently it could be sensible to implement a landfill to permanently or temporarily store the excess sludge that could not be incinerated.	The landfilling capacity provided by a landfill site would allow to store the sludge during the maintenance period of the incinerator and to avoid oversizing the incinerator due to the impossibility to precisely know the future sludge production of Chisinau WWTP.	If no landfill site is available to store the sludge that cannot be incinerated – existing situation – then a dedicated landfill site must be built, which increases the global CAPEX.
Agricultural use and landfill		
As for incineration, agricultural use may be subject to temporary unavailability due to many factors (restriction of usage, too little storage capacity at Chisinau WWTP due to a high sludge production, specific pollution resulting in a contaminated sludge, etc.). An alternative route for sludge disposal would allow more flexibility in the whole sludge management system.	The landfilling capacity provided by a landfill site would allow to store the sludge that cannot be spread on agricultural land.	If no landfill site is available to store the sludge that cannot be spread on agricultural land – existing situation – then a dedicated landfill site must be built, which increases the global CAPEX.

3.3.11.3. Barriers to the final disposal options

Waste-to-energy projects

The legal framework allowing the production of energy from waste in Moldova - as implemented in incineration, co-incineration or sludge anaerobic digestion projects - does exist in theory but it seems that financial and technical issues have not been completely solved yet, especially when selling the produced electricity to the distribution company is required (Table 37).

However, when the produced energy is not sold to a distribution company and is entirely consumed by the energy producer itself, it appears that projects may succeed, as exemplified by the biogas plant built by Thecogas in a cattle farm (Section 10).

Consequently it is believed that ACC is likely to face difficulties to implement a waste-to-energy project that includes selling electricity to the a distribution company, while implementing a waste-to-energy project that supplies energy directly to the ACC facilities (WWTP or others) will certainly be much easier.

Table 37 Extracts taken from “An Analysis of the Policy Reform Impact on Renewable Energy Projects Implementation in Republic of Moldova” UN Project ECE/GC/2008/033, November, 2009

Extract #1 Even the created framework for investments in renewables permitted investors to enter in the country power market, there has been no one renewable power generation unit build in the Republic of Moldova since power market reforms have been launched, except those financed through technical assistance came from foreign donors, as 100 kW PP on biogas built in village Colonita, not far from Chisinau. The last tried not one time to sign a contract of selling the surplus of electricity to the distribution company, but each time failed.
Extract #2 Based on published Law on Renewable Energy (2007), ANRE has elaborated the Methodology for the determination, approval and application of tariffs for the electricity generated from renewable energy and biofuels (February 2009). b) For RES based on Waste Incineration GO is issued for electricity produced exclusively from waste only. The share part of electricity produced by RES on waste is determined for by grid operator each month taking into consideration the incineration technology applied and the quantity of fossil fuel used. c) ANRE is placing on its web site the detail information on GOs issued by grid operator each month.

Incineration

The lack of adequate legal framework related to the incineration of waste - sludge included - in Moldova poses a threat to the acceptability of this technical solution by local authorities. This barrier could be overcome if an EU compliant regulation is adopted in Moldova, as it is soon expected.

Another barrier could emerge from the NIMBY (Not In My Backyard) syndrome that is generally experienced by planners of the facilities which do not benefit from a positive image from the public, such as incineration plants.

Agricultural use

Although a legal framework does exist in Moldova to rule the use of sludge in agricultural activities, and despite the positive opinion expressed by a local specialized agronomical institute, no practical implementation of this sludge disposal option has been reported in the country. This status likely originates from the reluctance of farmers to use the sludge produced by WWTPs, which is seen as a waste rather than a valuable product for soil fertilizing. This situation is common in many countries and the difficulties to overcome this barrier should not be underrated. A lot of efforts and time are generally needed to inform the stakeholders, to demonstrate the technical feasibility and to finally convince the farmers.

3.3.11.4. Conclusion

Considering the choice made for the PIP and the implementation of anaerobic sludge digestion, it is recommended to develop an adequate framework both in terms of adapted regulations and of practical organization of the whole chain of stakeholders (ACC, relevant public authorities, association of farmers) in order to start as soon as possible the implementation of the agricultural use of digested and dewatered sludge.

As a safety measure and back-up disposal option, it is also recommended to plan for the construction of a small landfill that could advantageously couple to a solid waste landfill and supplement the existing storage capacity in the future although this option is highly sensitive to disposal costs (transportation), which are not known yet because the landfill does not exist.

4. ACC MEASUREMENT CAMPAIGN IN DECEMBER 2011

Laboratory investigation results on wastewater quality at the entry of Chisinau WWTP, up to the connection of drainage systems and discharged water (P.1[1])

Date	pH	Alkalinity	PO_4^{3-}	P total	NH_4^+	N total	NO_2^-	NO_3^-	S^{2-}	Cr total	Iron total	Zn^{2+}	Cu^{2+}	Ni^{2+}	TSS	TS	COD	BOD5
Average	**7,4**	**22,37**	**11,3**	**3,75**	**40,3**	**44,51**	**0,09**	**0,19**	**1,2**	**0,08**	**1,11**	**0,04**	**0,03**	**0,05**	**288**	**772**	**535**	**222**
28/11/11	7,6	23,24	10,2	3,33	39,1	44,7	0,09	0,5	1,3	0,09	1,57	0,003	0,03	0,06	215	828	601	241
29/11/11	7,5	23,24	9,1	2,97	50,5	60,9	0,11	0,17							347	814	543	266
30/11/11	7,5	23,52	8,5	2,78	36,7	40,2	0,08	0,18							373	746	543	218
01/12/11	7,1	21,56	8,7	2,85	34,4	38,1	0,1	0,13							225	764	485	197
02/12/11	7,2	22,15	8,2	2,73	37,9	42,3	0,1	0,23							203	802	504	224
05/12/11	7,3	23,46	12,9	4,25	36,7	39,1	0,1	0,38	1,1	0,066	0,81	0,002	0,03	0,05	284	776	534	201
06/12/11	7,6	20,12	17,6	5,92	50,2	54,3	0,11	0,27							335	720	563	249
07/12/11	7,5	21,39	16,6	5,52	45,9	48,5	0,13	0,1							240	818	543	224
08/12/11	7,4	22,75	10,4	3,51	34,5	37,7	0,09	0,14							251	778	524	203
09/12/11	7,7	22,86	10,6	3,54	33,9	37,4	0,07	0,2							192	718	466	196
12/12/11	7,6	19,96	10,8	3,55	37,1	41,5	0,09	0,11	1	0,068	0,96	0,004	0,03	0,05	229	786	597	232
13/12/11	7,5	23,96	11,1	3,59	42,9	46,5	0,07	0,14							472	754	515	212
14/12/11	8,2	22,97	10,4	3,39	45,7	49,9	0,07	0,11							249	804	577	241
15/12/11	6,8	22,24	14,5	4,73	35,6	39,4	0,08	0,16							208	664	494	211
16/12/11	7,6	23,52	10,4	3,52	43,1	47,1	0,05	0,11							500	800	536	211

Note 1: Laboratory investigations have been executed according to Seureca initiated schedule, based on the approved order, nr 142 from 05.12.2011

Note 2: The samples have been taken every hour during 24 hours, and the investigations have been made considering the average from the collected samples during 24 hours.

Elaborated by: Head of Wastewater Laboratory, I. Tataru

Coordinated by: Head of Laboratory Service, I.Cascaval

5. EXISTING SATELLITE WWTPS

5.1. VADUL LUI VODA WWTP

5.1.1. BRIEF DESCRIPTION

Vadul lui Vodă WWTP is designed to treat the wastewater from the surrounding residential/tourist area and the industrial/farming industrial activities such as poultry farms and wineries in the village of Balabanesti.

Vadul lui Vodă WWTP was built in 1975 and no major modifications or renewal works have been done since then. The plant is operated by a sub-division of ACC.

The flow to be treated is highly fluctuating throughout the year and seasonal variations mainly originate from the tourist resorts nearby.

There is no flow meter on the plant. Flow rates are estimated based on working hours of some pumps.

Some figures related to the operation of the plant are presented below:

- Design capacity : 5,600 m3/d (or 5,200 m3/d, depending on the source)
- Average daily flow rate in 2010 : 1,957 m3/d
- Air flow rate : 360 L/s (i.e. 1,300 m3/h)

The plant features 4 similar treatment lines, among which 2 are currently not in use. The treatment steps are described below and illustrated by the pictures below:

- Raw wastewater pumping
- Grit removal (out of order)
- 2 sand removal systems (out of order)
- Splitting chamber
- Primary settling tank
- Primary sludge stabilization (then transferred to the biological tank)
- Biological tank (continuously aerated)
- Secondary clarifier
- Sludge recirculation to the biological tank.
- Excess sludge is transferred to drying beds (then the sludge is spread over a field nearby, although this procedure is not formally authorized) approximately once every week based on the MLSS concentration in the biological tank.
- Disinfection tank (with chlorine injection, not in use)
- 2 lagoons in series (50 x 100 x 3 m each)
- Discharge into a stream and then to the Nistru River

	
Inlet to the plant	Parshall canal
	
Pirmay sludge stabilization tank	Primary settler
	
Biological aerated tank	Secondary clarifier and open channel for the recirculated sludge

	
Disinfection tank	Sludge drying beds
	
Second lagoon with final discharge to the stream nearby	Blower room

5.1.2. CURRENT CONDITIONS

5.1.2.1. Wastewater flow rate

The wastewater flow treated at Vadul lui voda WWTP is estimated based on the working hours of the pumps located at the pumping stations (1 in the forest and 1 in a street next to a 9-storey building). One of them is said to include 2 pumps of 200 m3/h each.

The monthly average wastewater flow rate can double due to the influence of rain water (Figure 36).

The daily average flow rate over the period 2008-2010 is approximately 1,712 m^3/d.

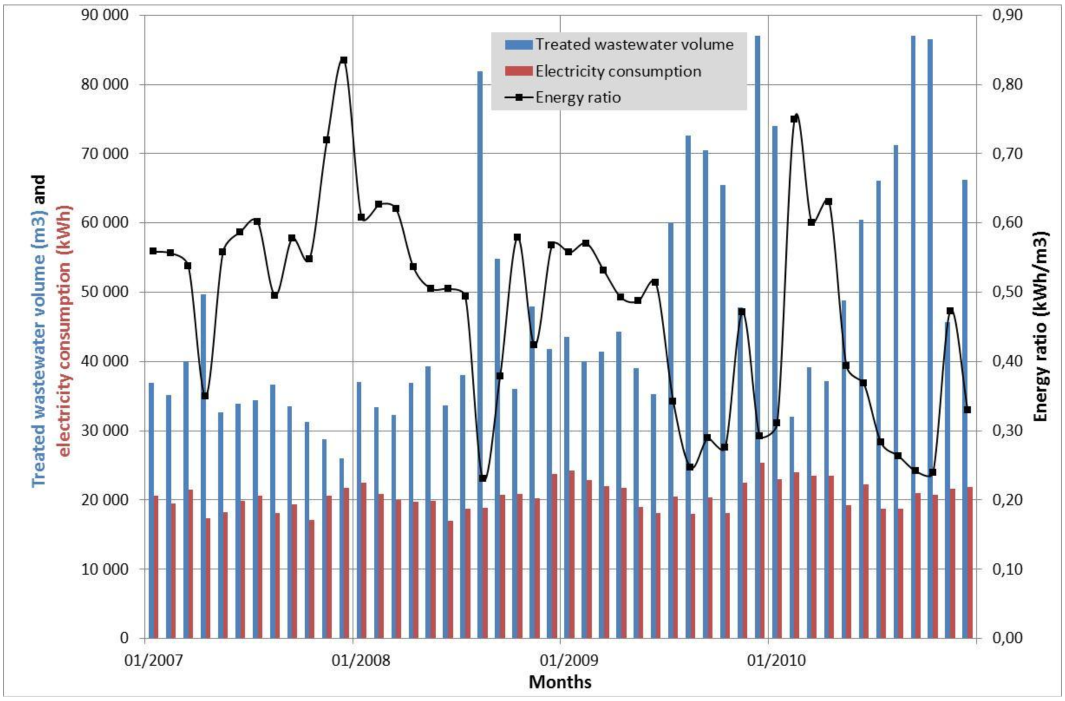


Figure 36 Monthly wastewater volumes and electricity consumption at vadul lui voda WWTP

5.1.2.2. WWTP performances

Energy ratio greatly varies in the range 0.2 - 0.8 kWh/m3 depending on the variations of the wastewater flow rates while the energy consumption remains fairly constant at around 20,000 kWh/month).

The average raw wastewater composition presented in Table 38 shows that the influent is very diluted (a high flow rate of intrusive water is suspected) and that nitrification is achieved at the WWTP (15 mg/L of nitrate in the outlet).

Table 38 Average quality of the inlet and outlet of Vadul lui voda WWTP (period 2008 – 2010)

	pH	BOD5	COD	TSS	Grease	TP	NH4	TDS	Oil	SO4	NO2	NO3
	-	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Inlet	7.5	73	174	153	9.2	3.5	14	758	2.9	146	0.4	2.0
Outlet	8.0	12	67	14	1.9	2.1	2	752	0.2	151	0.6	15.4

5.1.2.3. Condition of assets

The condition of the civil works and of the mechanical and electrical assets is the same as in Chisinau WWTP, which means that extensive rehabilitation - if not total reconstruction -should be planned in the near future in case the very existence of a WWTP in Vadul lui voda is deemed relevant.

5.1.3. RECOMMENDATIONS

Vadul lui voda WWTP is in poor global condition but its performances do comply with EU standard for carbon and nitrogen removal thanks to the high dilution of the influent. The relevance of building a new WWTP should be related to the global strategy of ACC regarding centralized versus decentralized wastewater treatment (see wastewater network).

5.2. COLONITA WWTP

5.2.1. BRIEF DESCRIPTION

Colonita WWTP was built in 1974 and is operated by 4 ACC operators. The design capacity of Colonita WWTP is reported to be 400 m3/d, but it is only treating around 250 m3/d (see Section 5.2.2).

The plant does not feature any pump or any instrument.

The plant is organized in one single treatment train which implements the following treatment steps:

- First tank: aeration of the raw wastewater with some uncontrolled mixed liquor intrusion from the second tank.
- Second tank: biological aerated tank
- Secondary clarifier (very basic)

The pumping of the recirculated sludge to the biological tank is done through an airlift pumping system.

The treated wastewater flows by gravity to two (or four?) lagoons in series - accounting for a total area of 3,900 m^2 - and is finally disinfected by chlorination (injection of pure Cl_2) before being discharged into a small stream.

The sludge extraction is done manually every 2 to 3 hours. The sludge flows by gravity towards the drying beds.

	
WWTP entrance	Inlet channel
	
Raw wastewater aeration tank	Biological tank with recirculated mixed liquor

	
Secondary clarifier	Blower room
	
Drying beds	Untitled

5.2.2. CURRENT CONDITIONS

5.2.2.1. Wastewater flow rate

The wastewater flow rate is estimated by the operators through the measurement of the water depth in the inlet channel once every 4 hours during the daily shift. The flow rate is then calculated by taking into consideration the characteristics of the inlet channel. This method is robust and does not require any equipment other than a scale, but is not precise. Therefore the wastewater flow rates values presented in Figure 37 should be taken as rough estimates only.

The wastewater flow rate is rather constant and generally lies between 7,000 and 8,000 m^3/month, with a daily average over the period 2008-2010 of approximately 260 m^3/d.

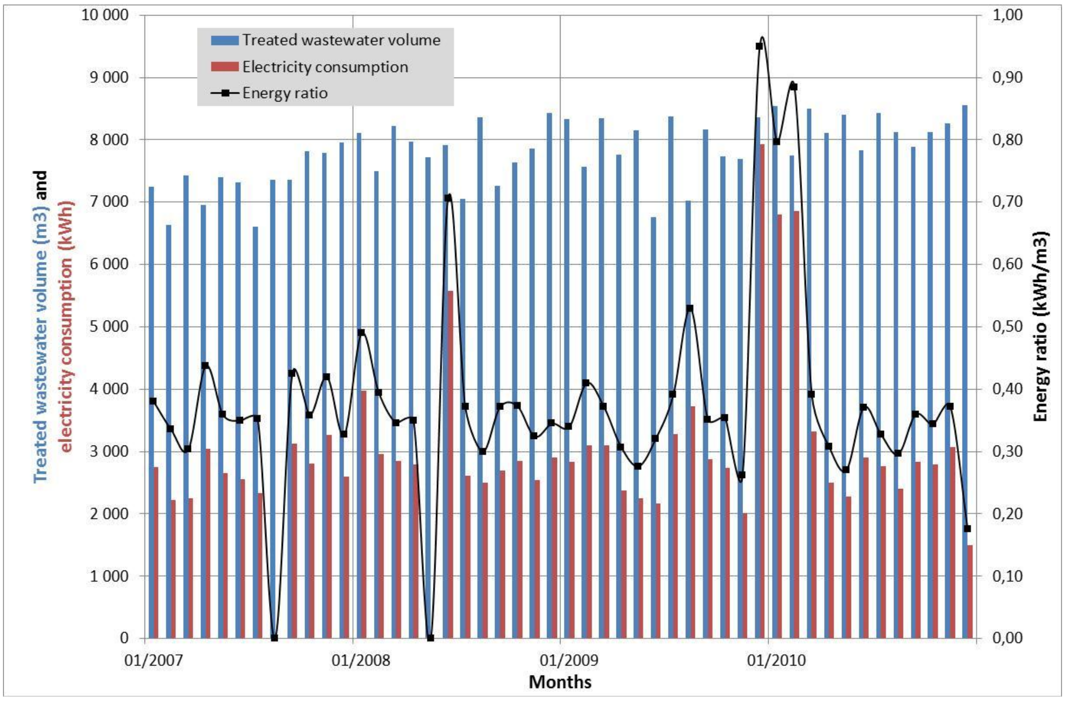


Figure 37 Monthly wastewater flow rates and electricity consumption at Colonita WWTP

5.2.2.1. WWTP performances

Energy ratio usually lies within the range 0.3 - 0.4 kWh/m3.

The average raw wastewater composition presented in Table 39 shows that the influent is a typical municipal wastewater of a moderate strength (much less diluted that in Vadul lui voda) and that partial nitrification is achieved at the WWTP (5 mg/L of nitrate in the outlet).

Table 39 Average quality of the inlet and outlet of Colonita WWTP (period 2008 – 2010)

	pH	BOD5	COD	TSS	Grease	TP	NH4	TDS	Oil	SO4	NO2	NO3
	-	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Inlet	7.8	255	564	275	9.7	9.7	55	803	0.9	194	0.8	3.5
Outlet	7.9	32	147	25	2.4	8.6	39	789	0.2	132	0.8	5.2

5.2.2.2. Condition of assets

The condition of the civil works and of the mechanical and electrical assets is the same as in Chisinau WWTP, which means that extensive rehabilitation - if not total reconstruction - should be planned in the near future in case the very existence of a WWTP in Colonita is deemed relevant.

5.2.3. RECOMMENDATIONS

Colonita WWTP is in poor global condition and its performances do not comply with EU standard even for carbon removal (COD exceeds 125 mg/L in the outlet). The relevance of building a new small WWTP is questionable and relates to the global strategy of ACC regarding centralized versus decentralized wastewater treatment. (see wastewater network report).

5.3. GOIANUL NOU WWTP

5.3.1. BRIEF DESCRIPTION

Goianul Nou is one of the six Monoblok-T WWTPs in Moldova (Table 40). This type of WWTP has been developed by a Czech company called Topol Water for the wastewater treatment of small communities. It comes in different standard sizes directly available from the shelf. Section 7 presents the main characteristics of this packaged plant which implements the Sequencing Batch Reactor (SBR) process.

Year	Location	PE
2008	Lipkani	800
2008	Sadaklia	200
2007	Goianul Nou	200
2007	Pirita	100
2007	Štefan Vody	1700
2005	Rezina, Moldova	800

Table 40 Monoblok-T WWTP in Moldova (Source: http://www.topolwater.com)

The design of the WWTP was reviewed by the State Water Design Institute Acvaproiect (see Section 6). The design capacity is 31.5 m3/d, which represents 200 PE. The capacity can be doubled in case a future extension is required.

The construction works started in 2009 under the supervision of ACC. ACC has been operating the plant since 2010. There is no operator on-site. All signals – the number and nature of these signals are not known – are reported to be sent to the « dispatching center » of ACC.

The plant is located underground plant and the treated water is intermittently discharged into a small river.

General view of Goianul Nou WWTP

Discharge of treated water into a small river nearby

5.3.2. CURRENT CONDITIONS OF THE WWTP

5.3.2.1. Wastewater flow rate

No data about the wastewater flow rates treated at Goianul Nou WWTP have been made available.

5.3.2.2. WWTP performances

No data about power consumption have been made available.

The only data available consist in the analytical sheet below which shows that the influent is very diluted (COD: 210 mg/L, NH4: 10 mg/L) and that full nitrification occurs (NH4 concentration is below 0.5 mg/L in the outlet).

S.A."Apă-Canal Chișinău"

Indicii de calitate a apelor uzate transportate la SE Goianul Noi și supuse epurării pe anul 2011

Nr.ctr.	Durlești	Unit de măsură	intrare ieșire	Trimestr I 23.03.2011	Trimestr I Medie	Trimestr II	Trimestr II Medie	Trimestr III	Trimestr III Medie	Trimrestr IV	Trimrestr IV Medie	Medie pe an 2011
1	Reacția activă pH		intrare	8,15	8,15		0,00		0,00		0,00	2,04
			ieșire	8,30	8,30		0,00		0,00		0,00	2,08
2	CBO5	mgO2/dm3	intrare	96,00	96,00		0,00		0,00		0,00	24,00
			ieșire	7,20	7,20		0,00		0,00		0,00	1,80
3	CBO20	mgO2/dm3	intrare	127,68	127,68		0,00		0,00		0,00	31,92
			ieșire	9,58	9,58		0,00		0,00		0,00	2,40
4	CCO	mgO2/dm3	intrare	210,00	210,00		0,00		0,00		0,00	52,50
			ieșire	25,00	25,00		0,00		0,00		0,00	6,25
5	Substanțe in suspensie	mg/dm3	intrare	305,00	305,00		0,00		0,00		0,00	76,25
			ieșire	10,00	10,00		0,00		0,00		0,00	2,50
6	Grăsimi	mg/dm3	intrare	25,80	25,80		0,00		0,00		0,00	6,45
			ieșire	2,20	2,20		0,00		0,00		0,00	0,55
7	Fosfor total	mg/dm3	intrare	12,50	12,50		0,00		0,00		0,00	3,13
			ieșire	3,20	3,20		0,00		0,00		0,00	0,80
8	Azot de amoniu	mg/dm3	intrare	10,60	10,60		0,00		0,00		0,00	2,65
			ieșire	0,30	0,30		0,00		0,00		0,00	0,08
9	Compoziția minerală	mg/dm3	intrare	1010,00	1010,00		0,00		0,00		0,00	252,50
			ieșire	1040,00	1040,00		0,00		0,00		0,00	260,00
10	Detergenți (SSAS)	mg/dm3	intrare	0,400	0,400		0,00		0,00		0,00	0,10
			ieșire	0,040	0,040		0,00		0,00		0,00	0,01
11	Cloruri (CL-)	mg/dm3	intrare	80,00	80,00		0,00		0,00		0,00	20,00
			ieșire	72,00	72,00		0,00		0,00		0,00	18,00
12	Sulfați (SO 2-)	mg/dm3	intrare	120,00	120,00		0,00		0,00		0,00	30,00
			ieșire	80,00	80,00		0,00		0,00		0,00	20,00
13	Nitriți	mg/dm3	intrare	0,010	0,01		0,000		0,00		0,000	0,003
			ieșire	0,020	0,02		0,000		0,00		0,000	0,005
14	Indicele coli, CBLP	LCP/dm3	intrare	$2,2 \times 10^6$	$2,2 \times 10^6$							
			ieșire	$1,6 \times 10^5$	$1,6 \times 10^5$							
15	Indicele coli-fage	UFP/dm3	intrare	$2,2 \times 10^4$	$2,2 \times 10^4$							
			ieșire	$1,0 \times 10^2$	$1,0 \times 10^2$							

Avizat: Șef DACCR A.Rusnac

Elaborat: Șef interimar SACRE S.Platonova

5.3.2.1. Condition of assets

The plant has been in operation since 2010 only. The works are in good conditions and no major defect has yet been reported.

5.3.3. RECOMMENDATIONS

This new plant is in good overall condition but its performances could not be assessed. From a broader perspective the relevance of building and operating such a small plant can be questioned. This issue is related to the strategy that should be decided by ACC regarding centralized or decentralized wastewater treatment as far as villages surrounding Chisinau are concerned. (see wastewater network report).

6. ACVAPROIECT

source:http://www.eecca-water.net/index.php?option=com_content&task=view&id=166&Itemid=40&lang=english

According to the Government's Decrees of the Republic of Moldova, the State Water Design Institute "Acvaproiect" performs the functions of:

- head basin design institution in the republic
- head organization for preparation of construction documents for high-water dams and their structures
- head design institution for development of water use and protection master plans and for design of hydrotechnical structures

The Institute was founded by the Republican water-management trust "Apele Moldovei" at the Moldova's Ministry of Agriculture and Food Industry.

Financial activity is performed on full self-supporting basis.

The Institute's practical activities are as follows:

- developing plans of hydrotechnical structure development and location, as well as plans of rural water supply
- drawing up plans of integrated water use and protection
- comprehensive planning of water supply and sanitation systems
- comprehensive planning of irrigation and drainage systems
- designing protection of urban and rural settlements and agricultural land from flooding and water-logging
- developing designs for ponds and reservoirs, elaborating measures for enhancement of beam systems and anti-landslide actions
- designing hydrotechnical structures, pumping stations, fish-protection structures, transformer substations, power transmission lines, automation and communication lines
- developing project plans for cleaning of river channels and water bodies and for re-cultivation of disturbed land
- designing and constructing artesian and observation wells, dug wells, tapping springs
- designing hydrotechnical structures in order to use non-conventional energy sources
- conducting geological engineering and soil surveys
- studying water quality, preparing and issuing relevant certificates
- designing industrial and civil engineering structures
- supplying construction sites and enterprises with necessary equipment and materials

Website: http://www.acva.md

7. MONOBLOK - T

7.1. DESCRIPTION


Monoblok-T: Mitrov 200 PE


Monoblok-T: 250 PE

Monoblok-T is a biological wastewater treatment plant with intermittent operation of sequencing batch reactor (SBR). It consists of an accumulation tank, SBR tank and sludge tank. The complete operation is control via a PC. This allows the wastewater treatment plant (WWTP) to vary the parameters of processing depending upon the quality and volume of water.

The Monoblok-T can additional be equipped with a remote access unit, allowing control, measure and reporting to be undertaken anywhere in the world. However, this is reliant on availability to either a standard telephone line for internet access or with a GSM system. This provides the option for the operation of the WWTP to be fully automated and controlled from a central head office.

Monoblok-T can be installed for municipal wastewater demands or industrial wastewater where biological treatment may be required. WWTP of this type are usually installed for capacities from 100 PE to 1,000 PE.

Monoblok-T WWTP guarantees high quality of treated water (nom. BOD5 10 mg/L or below).

The complete WWTP of Monoblok-T includes an accumulation tank, SBR tank, aeration tank and an excess sludge tank. For monolithic concrete foundations all tanks are usually rectangle in shape and built up as one structure that can be partly or fully covered. A small operation house built in either wood/brick allows the control units to setup and monitored. The Monoblok-T system is also suitable for intensification and expansion or re-construction to improve the efficiency and effectiveness of existing WWTP.

The Monoblok-T system is protected by Patent No. 283 156

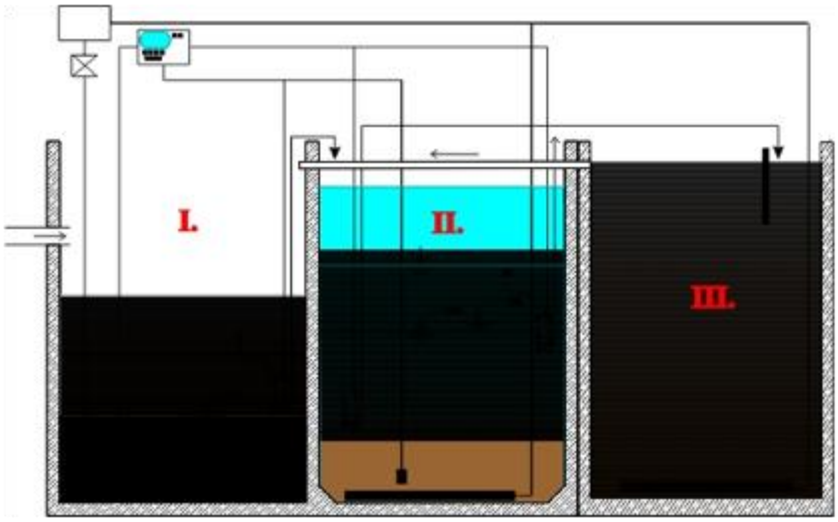
7.2. THE PROCESS

Wastewater flows into the accumulation tank, which also initiates as the 1st stage of activation and can be utilised as an excess sludge storage tank for low volumes. In most cases an additional excess sludge tank is incorporated.

From the accumulation tank the pre-treated water is pumped into the SBR tank, where by the flow switches are activated in pre-defined parameters in PLC unit to start the aeration process. Once the aeration process has finished the SBR tank moves into the sedimentation phase, this allows the heavy sludge, particles, etc. to fall to the bottom of the tank. The top third of the tank of treated water is now ready to be decantered. This process simply enables the decanter arm to semi-submerge allowing the treated water to filter in via the water outlet hole.

Finally the treated water flows then onto either a storage tank or back into a natural resource.

7.3. MONOBLOK – T - DIAGRAM

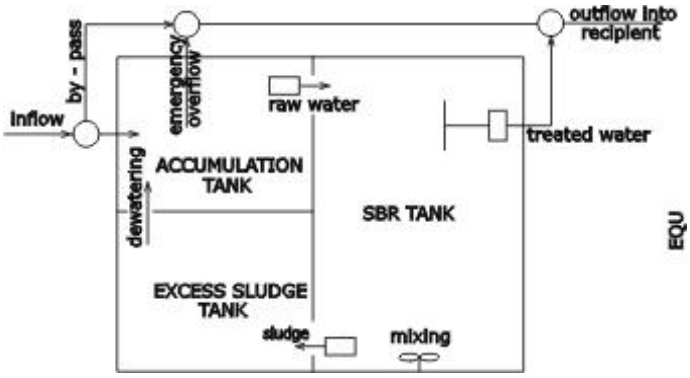


Key
I = Accumulation Tank

II = SBR Tank

III = Excess Sludge Tank

Flow Diagram



7.4. ADVANTAGES OF MONOBLOK-T

Output of high quality treated water. BOD5 is approx 5 mg/L.

The process is fully automated, allowing a single person remotely to control and monitor multiple operations which minimises the daily maintenance costs.

The process can also be adapted to industrial uses where biological treatment is additionally required.

Source: http://ridgeford-ind.co.uk/wwtp_municipal.shtml

8. OVERVIEW OF THE ELECTRICITY SECTOR IN MOLDOVA

Internet sources:

http://www.energyplus.utm.md/

www.anre.md

Sources of electrical energy:

There are three electricity producers in Moldova

Some electricity is imported from Ukraine

Some electricity is imported from Romania

General electrical distribution

For tension above 10 kV, Moldelectrica is in charge of the distribution

Electrical distribution to customers

Many companies. Union fenosa in Chisinau.

	Rate from 19/01/2010 MDL/kWh	New rate from 15/04/2011 MDL/kWh	Evolution %
RED Union Fenosa			
- For consumers connected to high voltage networks (35 - 110 kV)	0.95	1.07	13%
- For consumers connected to medium voltage networks (6 - 10 kV)	1.33	1.34	1%
- For consumers connected to low voltage networks (up to 0.4 kV)	1.33	1.48	11%
RED Nord			
- For consumers connected to medium voltage networks (6 - 10 kV)	1.43	1.45	1%
- For consumers connected to low voltage networks (up to 0.4 kV)	1.43	1.57	10%
RED Nord- Vest			
- For consumers connected to high voltage networks (35 - 110 kV)	1.43	1.20	-16%
- For consumers connected to medium voltage networks (6 - 10 kV)	1.43	1.45	1%
- For consumers connected to low voltage networks (up to 0.4 kV)	1.43	1.57	10%

8.1. ELECTRICITY TARIFFS HAVE BEEN RAISED

Source: http://www.allmoldova.com

15 april 2011, 14:00

The National Agency for Energy Regulation on April 15 set new electricity prices for end-users, at the request of the power suppliers RED Union Fenosa, RED Nord and RED Nord-Vest. For the first time, the Agency fixed different tariffs, depending on the voltage in the power distribution networks, Info-Prim Neo reports.

For the consumers supplied by RED Union Fenosa through low voltage power lines (0.4 kV), the price will be 1.48 lei/kWh, for those connected to medium voltage power lines (6-10 kV) – 1.34 lei/kWh, while for those connected to high voltage power lines (35-110 kV) – 1.07 lei/kWh.

The charges for the end-users supplied by RED Nord will be 1.45 and 1.57 lei/kWh, depending on the lines to which they are connected.

The customers of RED Nord-Vest will pay 1.57 lei/kWh, 1.45 lei/kWh, and 1.20 lei/kWh respectively.

The rises for different categories of end-users varied between 0.8 and 11.3%. The tariff for the consumers supplied by RED Nord-Vest through high voltage power lines was decreased by 16.1%.

The tariffs for end-users were increased following the rise in the average purchase price of electric power, the power transportation tariff and the costs for maintaining the power distribution networks. The Agency decreased a part of the consumption and costs that the suppliers asked to be included in the tariff. The costs for RED Union Fenosa were reduced by 14.5 million lei, while for RED Nord and RED Nord-Vest – by 2.5 million lei and 9.8 million lei respectively.

The new tariffs will take effect after they are published in the Official Gazette. The last time the electricity prices were adjusted last January.

9. DECISION #606 OF THE MOLDOVAN REPUBLIC

9.1. EXTRACTS IN ROMANIAN

HGM606/2000

HOTĂRÎRE Nr. 606 din 28.06.2000

privind aprobarea Programului naţional de valorificare a deşeurilor de producţie şi menajere

[...]

D. Deşeurile rezultate la tratarea şi epurarea apelor

Sursele principale de producere a deşeurilor sînt:

1. staţiile de tratare a apei potabile;
2. staţiile de epurare a apelor menajere şi industriale;
3. staţiile de epurare a apelor meteorice şi a apelor de la spălarea automobilelor.

Actualmente în Republica Moldova la staţiile de tratare a apei potabile se acumulează anual peste 20 mii tone de nămoluri. Din lipsa instalaţiilor de epurare a apelor provenite de la spălarea filtrelor şi a utilajului de deshidratare a nămolului nu se duce evidenţa nămolului format de fiecare întreprindere, nu sînt condiţii pentru depozitarea şi utilizarea lui. Deshidratarea nămolului în cele mai bune cazuri are loc în condiţii naturale în bazine acumulatoare cu depozitarea ulterioară la rampele degunoi. La aceste întreprinderi apele de la spălarea filtrelor nu se utilizează, fapt care vine în contrazicere cu cerinţele actelor normative şi legislative în vigoare. Nu este soluţionată problema deşeurilor lichide provenite de la staţiile de epurare a apelor reziduale industriale şi meteorice.

În prezent instalaţiile comunale de epurare a apelor uzate au o capacitate de 664 mii m3/zi. Volumul sedimentului format în rezultatul funcţionării acestor instalaţii constituie un milion m3/an. În majoritatea cazurilor deshidratarea sedimentelor se produce la cîmpurile de nămol cu o suprafaţă totală de circa 82 ha.

Sedimentele sînt deshidratate pînă la umiditatea de 75-80% timp de 10-20 zile. Dehelmintizarea nămolului se efectuează doar parţial (50-60%).

Dezinfectarea sanitară, prezenţa macro- şi microelementelor necesare pentru creşterea plantelor face posibilă utilizarea sedimentelor în gospodăria urbană în calitate de îngrăşăminte organice. Sedimentele de la instalaţiile de epurare a apelor meteorice actualmente nu sînt supuse evidenţei. Lipsesc terenurile de deshidratare a lor, nu se ţine cont de volumul şi metodele utilizării nămolului, inclusiv a celui poluat cu tetraetil plumb.

În mun. Chişinău firma indiană "BAPL" a început construcţia unei staţii de tratare a nămolului din instalaţiile comunale, însă din lipsa asigurării financiare lucrările au fost sistate. S-au elaborat proiecte pentru construcţia unor staţii de deshidratare mecanică a namolurilor în mun. Bălţi, or. Orhei şi Ştefan Vodă, care vor soluţiona parţial această problemă.

Ţinînd cont de cele expuse şi întru ameliorarea stării mediului în republică, în programul de valorificare a deşeurilor sînt incluse măsuri concrete (pct. 50-55 din comp.XI).

[...]

Extras din Planul de actiuni in conformitate cu HG 606

50	Organizarea şi efectuarea investiţi- ilor asupra compoziţei şi calităţii nămolurilor de la staţiile de	Autoritatile Publice Locale, Ministerul Mediului si Amenajarii Teritoriului, Institutul de Chimie	2001-2002

	epurare a apelor uzate şi elaborarea recomandarilor privind utilizarea lui		
51	Inventarierea instalatiilor de tratare a apei potabile si de epurare a apelor uzate in scopul determinarii volumelor namolurilor captate si neutilizate si gradul de indeplinire a lucrarilor la obiectele respective (in faza de constructie)	Ministerul Mediului si Amenajarii Teritoriului, Autoritatile Publice Locale	2001-2002
52	Elaborarea documentatiei de proiect si constructia instalatiilor de epurare a apelor provenite de la spalarea filtrelor la statiile de tratare a apei(acolo unde ele lipsesc)	Ministerul Mediului si Amenajarii Teritoriului, Autoritatile Publice Locale	2001-2003
53	Efectuarea investigatiilor agrotehnice ale namolurilor de la statiile de epurare in scopul determinarii modului de utilizare a lor in calitate de ingrasaminte orghanice in agricultura si silvicultura, cu elaborarea proiectelor respective	Ministerul Mediului si Amenajarii Teritoriului, Ministerul Agriculturii si Industriei Prelucratoare, , Autoritatile Publice Locale, Primaria municipiului Chisinau, CS "Apă-Canal"	2002-2003
54	Elaborarea documentelor de proiect, executarea lucrarilor de constructie privind dshidratarea namolurilor de la instalatiile mun.Chisinau	Primaria mun.Chisinau, CS “Apa-Canal”	2001-2005
59	Elaborarea documentatiei de proiect si executarea, in baza studiului de fezabilitate, a lucrarilor pentru obtinerea biogazului la statiile de epurare a apelor uzate din mun.Chisinau, Balti si alte localitati	Ministerul Mediului si Amenajarii Teritoriului, Primariile mun. Chisinau si Balti, Primarii, C.S.”Apa-Canal”	2005
60	Finalizarea lucrarilor de constructie a instalatiilor de deshidratare a namolului de la statiile de epurare din mun.Chisinau, tininduse cont de modernizarea tehnologiilor	Primaria mun.Chisinau, C.S.”Apa-Canal”	2005

9.2. English translation

HGM606/2000

Decision # 606 dated 28.06.2000 for the approval of the National Programme for valorisation of industrial and domestic waste.

[...]

D. Waste resulting from water and wastewater treatment

The main sources of waste production are:

1. drinking water treatment plants
2. wastewater treatment plants and industrial
3. storm water treatment plants and water from car washing

Currently over 20,000 tons of sludge accumulate annually at water treatment plants in Moldova. The lack of treatment facilities from cleaning filters and sludge dewatering equipment does not allow the recording of sludge produced by each company, not conditions for storing and using it. In the best case sludge dewatering takes place under natural conditions in drying beds. Industrial customers do not filter water used for washing, which comes in contradiction with the requirements of normative and legislative acts in force. Not addressed the problem of sludge from wastewater treatment plants and industrial storm.

Sediments are dried until the moisture content reaches 75-80% for 10 to 20 days. Helminth eggs removal in the sludge is only partially performed (50-60%).

Disinfection of health, the presence of macro-and microelements necessary for plant growth makes the use of urban household sediments as organic fertilizer. Sediment from storm water treatment facilities are not currently subject to. Absence of drying them does not take into account the volume and methods of use of sludge, including the one polluted with tetraethyl lead.

Currently municipal wastewater treatment facilities have a capacity of 664,000 m3/day. The volume of sludge resulting from the operation of these facilities is one million m3/year. In most cases, sludge dewatering is performed in drying beds with a total area of about 82 ha.

The Indian company "BAPL" started the construction of a facility for the treatment of municipal sludge in Chisinau, but the works were stopped due to the lack of funds. Projects have been developed for the construction of mechanical dewatering facilities in Balti, Orhei and Stefan Voda, that will partially solve the problem.

Taking into account the fully exposed and environmental improvements in the country, concrete measures are included in the program for waste recovery (section 50-55 of comp.XI).

[...]

Extract from the action plan of HGM606/2000

#	Action	Institution in charge	Implementation period
50	Organization and investments on the composition and quality sludge from wastewater treatment plants and develop recommendations on the use	Local Public Authorities, Ministry of Environment and Spatial Planning, Institute of Chemistry	2001-2002
51	Inventory of drinking water treatment plants and sewage treatment in order to determine the volume of sludge collected and used and the degree of fulfilment of works on these objects (under construction)	Local Public Authorities, Ministry of Environment and Spatial Planning,	2001-2002
52	Develop project documentation and construction of water treatment plants from washing filters at water	Local Public Authorities, Ministry of Environment and Spatial Planning,	2001-2003

	treatment plants (where they are missing)		
53	Conducting investigations of agro sewage sludge from wastewater in order to determine how to use them as fertilizer in agriculture and forestry orghanice with the development of these projects	Ministry of Environment and Spatial Planning, Ministry of Agriculture and Processing Industry, "Local Public Authorities, Chisinau municipality, CS" Apa-Canal "	2002-2003
54	Develop project documents, execution of construction on the plants mun.Chisinau dshidratarea sludge	Chisinau municipality, CS "Apa Canal"	2001-2005
59	Develop project documentation and enforcement in the feasibility study, works for obtaining biogas from wastewater treatment plants in Chisinau, Balti and other localities.	Ministry of Environment and Spatial Planning, Chisinau and Balti Municipalities, CS "Apa Canal"	2005
60	Completion of the construction of sludge dewatering facilities to sewage treatment plants in Chisinau, taking into account the modernization of technologies.	Chisinau municipality, CS "Apa Canal"	2005

10. BIOGAS PRODUCTION IN MOLDOVA

http://thecogas.com/2010/05/18/biogas-project-moldava-near-to-chisinau/

Biogas project Moldova - (near to) Chisinau

18. May, 2010

In September 2005 Thecogas B.V. started to built a biogas plant in Moldava. The biogas plant was built on a big cattlefarm near the capital city Chisinau. The project started after Thecogas B.V. signed a contract with BTG (Biomass Technology Group) in Enschede. Thecogas contracted to have the concrete tank constructed locally, installed the isolation, the heat and power installations, the agitator and the pumps. Interesting is the corrugated sheets (we normally would use) have been replaced by stainless steel printing plates as cover material for the outside of the tank.

The CHP (combined heat power installation) has a power of 85 kW, and produces as much as energy as the company needs. Therefore, the installation won't provide energy back to the electricity network. See the picture below.

11. INCINERATION PROJECT IN CHISINAU

National case study: “An Analysis of the Policy Reform Impact on Renewable Energy Projects Implementation in Republic of Moldova”; November, 2009; United Nations – economic commission for Europe, Energy Efficiency 21 Programme; Project Number: ECE/GC/2008/033; Project Title: Financing Energy Efficiency Investments for Climate Change Mitigation

http://www.clima.md/files/EficientaEnergetica/Studii%20de%20caz/CaseStudyMoldova.pdf

11.1. TECHNICAL DESCRIPTION

11.1.1. CHISINAU WASTE TO ENERGY POWER PLANT (CH WTE PP)

Brief description: Because there is no any detailed information on the technology to be applied by the investor, it is assumed that it will correspond to ‘waste-to-energy’ one, widespread in the world, an example being AEB Amsterdam WTE [11].

The Plant will be built in the area of Municipality Chisinau, near to the existing Chisinau Wastewater Treatment Plant. WTE plants serve two purposes, environmental disposal of solid wastes and generation of electricity.

All amount of wastes generated in Chisinau will be incinerated at the respective plant; the energy produced being used for electricity generation. The technology to be applied is imported, and can be treated as know-how transfer. The dominant ‘waste-to-energy’ technology is combustion of “as received” municipal solid wastes (MSW) on a moving grate. The feeding hopper (Figure 1) of the mass-burn furnace is kept full of solid wastes. At the bottom of the hopper, a hydraulically operated ram feeder forces the solids onto the feed end of the grate. From there on, the bed of solids moves slowly towards the discharge end, due to gravity and the periodic motion of the grate bars. In many mass-burn furnaces, e.g. at the AEB Amsterdam WTE, the grate is a horizontal belt conveyer [7].

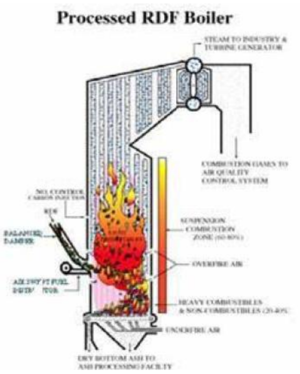


Figure 1: Processes RDF Boiler

11.1.2. MOLDOVA WASTE ENERGY POTENTIAL

According to [12], annually the municipality services of Moldova record around of 1,143-1,266 thousands m3 of Municipal Solid Waste (MSW) transported to the landfills. Base on the information accumulated related to the characteristics of the MSW and the number of population in the appropriate localities [14] the norm of MSW generated by a person has been calculated. It is ranged from 0.25 kg/inhabitant in Nisporeni or Cimislia to up to 0.8 kg/inhabitant in Balti and 1.3 kg MSW/inhabitant in Chisinau.

Extrapolating these values to others localities the following quantities of MSW assumed to be generated in the localities of the Republic of Moldova annually, including in Municipality Chisinau (Table 2).

The caloric value of Moldova MSW is much less that one from Western Europe and is equal to approximately 1100 kcal/kg [15]. The total value of energy contained in the annual generated Moldova's MSW is equal to 0.86 TWh, including 0.48 TWh/year in Chisinau MSW. Because of very low efficiency of WTE technology the electricity delivered for consumption from such PP could not exceed 0.095 TWh/year.

Table 2: Annual Generation of MSW in the Republic of Moldova

Locality	Inhabitants	Tones /year	Locality	Inhabitants	Tones / year	Locality	Inhabitants	Tones / year
Chisinau	785,087	372,708	Soroca	101,489	11,234	Telenești	74,916	7,233
Bălți	148,114	20,073	Anenii Noi	83,105	8,386	Ungheni	117,219	13,957
Briceni	76,590	7,463	Călărași	79,604	7,884	Basarabeasca	29,500	2,135
Dondușeni	46,388	3,774	Criuleni	72,787	6,945	Cahul	123,808	15,176
Drochia	91,492	9,641	Dubăsari	35,211	2,655	Cantemir	63,406	5,733
Edineț	83,884	8,499	Hîncești	123,499	15,118	Căușeni	92,904	9,859
Fălești	93,600	9,968	Ialoveni	97,987	10,664	Cimișlia	62,903	5,670
Florești	91,492	9,641	Nisporeni	67,386	6,235	Leova	53,896	4,600
Glodeni	62,893	5,669	Orhei	125,915	15,576	Ștefan Vodă	72,498	6,906
Ocnița	56,801	4,936	Rezina	53,200	4,521	Taraclia	44,609	3,587
Rîșcani	71,297	6,746	Strășeni	91,491	9,640	Găgăuzia	159,717	22,632
Sîngerei	93,906	10,016	Șoldănești	44,109	3,535			
TOTAL	**3,572,703 inhabitants**				**669,013 tones/year**			

In order to determine CO2 emission reduction from Chisinau WTE operation three factors have been taken into consideration: emission reduction from excluding CH4 generation from MSW in the landfill; CO2 emissions from natural gas burned, used to enrich and dry waste for burning; plus CO2 emission reduction from displacing electricity produced at traditional PP.

a) According to Table 4 of [13], specific CH4 generation from MSW is equal to 0.0516 t CH4/tMSW. Applying this value and the data from the table above, we are obtaining 403.72 thousand t CO2 emissions reduction from excluding CH4 generation.

b) Because of low caloric value of Chisinau MSW and high humidity of it, natural gas is used to enrich and to dry the waste fuel, in order to maintain burning in the burner of WTE PP. Around 48.11 million m3 of natural gas will be burned annually in this respect, producing approximately 90 thousand t CO2/year.

c) In order to calculate CO2 emission reduction from displacing electricity at traditional PP the conservative fuel is used for traditional power generation, i.e. natural gas for which IPCC [10] default value of 56.1 t CO2/TJ is applied. The electricity produced at Chisinau WTE PP will display the one produced at TrPP at which the efficiency does not exceed 40%. For such conditions, the CO2 emission reduction potential from Chisinau WTE PP would constitute 132.2 thousand t CO2/year.

The total CO2 emission reduction from Chisinau WTE PP operation will be equal to 445.9 thousand tCO2/year.

11.2. Financial description

11.2.1. Investments

Investments attracted for the implementation of Chisinau WTE PP project constitute around 200 million Euro [16].

11.2.2. Costs

It is premature to evaluate exactly the direct and indirect costs of the projects examined in conditions when they are not implemented yet. Even so some of the costs could be estimated:

Operation & Maintaining Costs for Chisinau WTE PP are determined based on Amsterdam WTE PP [11] O&M costs, the lasts being adjusted to the conditions of Chisinau. In particular, the average remuneration cost per employee is taken 10 times lower than for Amsterdam case.

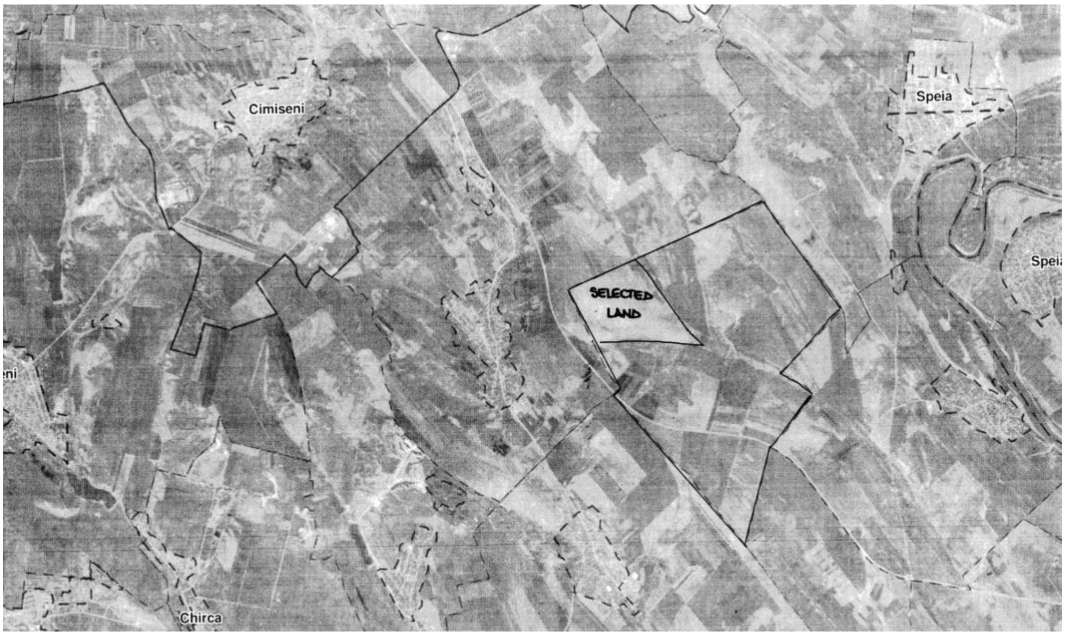
Table 3: Comparative Operation & Maintaining Costs for Chisinau and Amsterdam WTE PPs

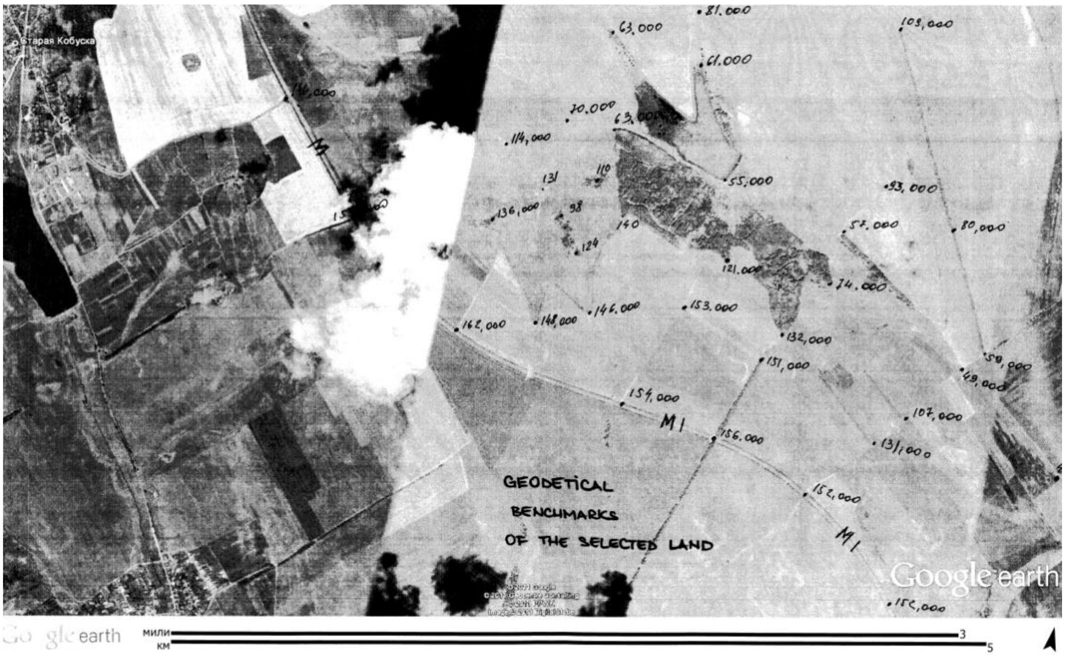
O&M Costs at WTE PP	Unit	Amsterdam WTE	Chisinau WTE
Number of waste processed	tone	800,000	372,665
Number of employees	persons	300	140
Number of employees per 1 tone processed	person/tone	0.000375	0.000375
Per month remuneration at WTE PP	Euro/month/person	3,911	403
Personnel costs	thou Euro	14,078	676
Maintenance costs	thou Euro	14,717	6,856
Residue processing costs	thou Euro	8,903	4,147
Rent and leases	thou Euro	16,827	1,500
Other operating expenses	thou Euro	11,751	1,000
TOTAL O&M costs	thou Euro	66,276	14,179

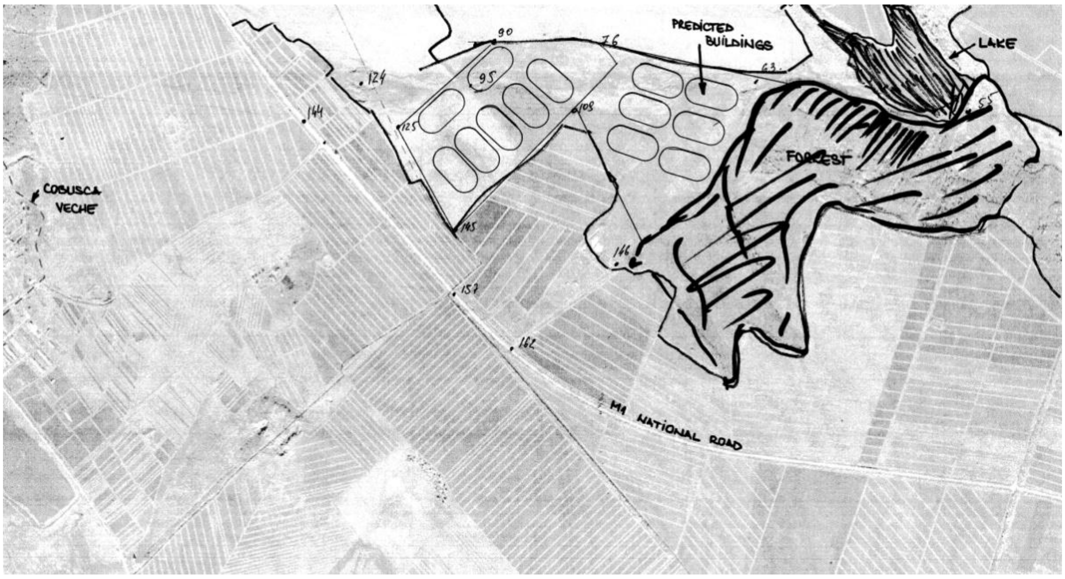
The total Chisinau WTE PP O&M costs will constitute 14.178 million Euro per year.

The lifetime of the plant is equal to 30 years [16], so that the annual depreciation will be 6.67 million Euros.

12. PROPOSED LANDFILL SITE



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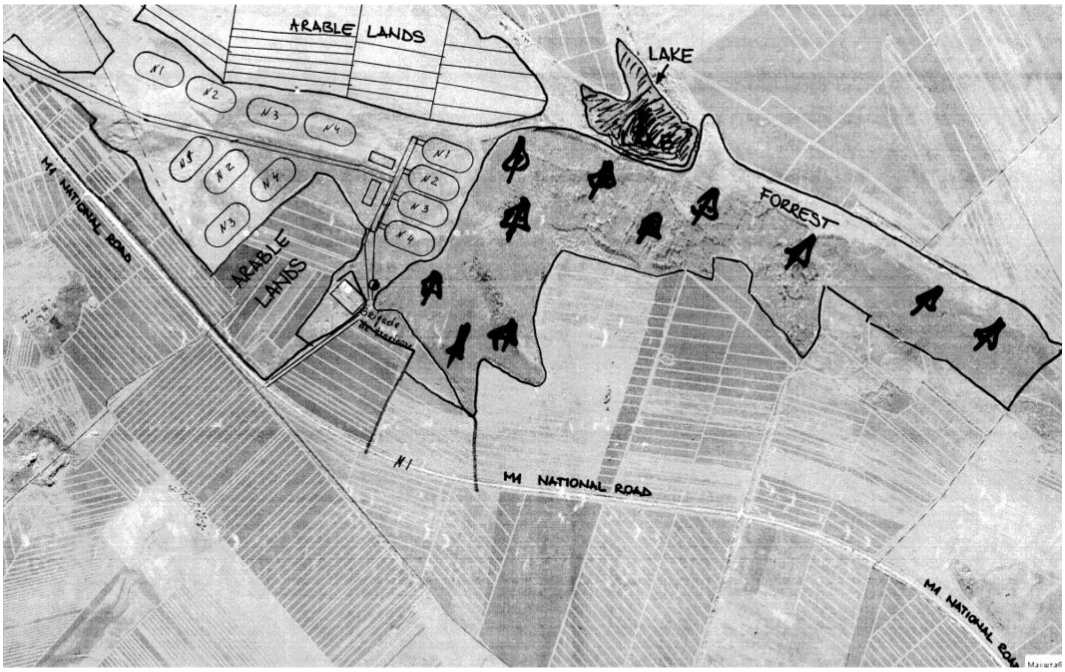
FORREST
COBUSCA VECHE
M1 NATIONAL ROAD


ARABLE LANDS
LAKE
FORREST
ARABLE LANDS
M1 NATIONAL ROAD
M1 NATIONAL ROAD
M1 NATIONAL ROAD

13. ANAEROBIC SLUDGE DIGESTION IN SELECTED EASTERN EUROPE WWTPS

Country	Location	Name of the plant	Capacity PE	Capacity m3/d	Sludge Treatment	End use	Quantity of sludge produced tSS/d	Odour treatment	Biogaz recovery	Details about Cogeneration (if any)
BULGARIA	SOFIA	KUBRATOVO	1,800,000	480,000	Anaerobic digestion Drying beds				Biogaz Recovery into Cogeneration (Heat and Electricity)	3 cogenerators. Each consumes 8,000 m3 of biogas per day. The energy generated by each unit is equal to 1,063 kWh of electrical and 1,088 kWh of thermal energy
CZECH REPUBLIC	HRADEC KRALOVE AND SURROUNDINGS	HRADEC KRALOVE	141,000	61,995	Anaerobic digestion, Dewatering by centrifuge	Landfill		NA	NA	NA
CZECH REPUBLIC	NORTH BOHEMIA	USTI NAD LABEM - NESTEMICE	169,000	51,840	Static thickening, Anaerobic digestion, Dewatering by centrifuge, Composting	Composting	7.7	NA	NA	NA
CZECH REPUBLIC	NORTH BOHEMIA	LIBEREC	90,333	54,806	Static thickening, Anaerobic digestion, Dewatering by centrifuge, Composting	Composting	6.06	NA	NA	NA
CZECH REPUBLIC	NORTH BOHEMIA	BYSTRANY	104,185	31,220	Anaerobic digestion, Dewatering by centrifuge, Composting	Composting	4.3	NA	NA	NA
CZECH REPUBLIC	NORTH BOHEMIA	CESKA LIPA	60,000	27,672	Anaerobic digestion, dewatering by centrifuge, Composting	Composting		NA	NA	NA
CZECH REPUBLIC	NORTH BOHEMIA	DECIN BOLETICE	68,000	13,608	Anaerobic digestion, Dewatering by centrifuge, Compostinging	Composting	1.95	Biological	NA	NA
CZECH REPUBLIC	NORTH BOHEMIA	LITOMERICE	97,970	9,312	Anaerobic digestion, dewatering by belt filter, Composting	Composting			NA	NA
CZECH REPUBLIC	NORTH BOHEMIA	MOST CHANOV	63,260	18,550	Anaerobic digestion, dewatering by centrifuge, Compostinging	Composting		NA	NA	NA
CZECH REPUBLIC	NORTH BOHEMIA	UDLICE	50,183	17,332	Anaerobic digestion, dewatering by centrifuge, Compostinging	Composting	2.05	NA	NA	NA
CZECH REPUBLIC	OLOMOUC	PROSTEJOV	108,000	21,500	Anaerobic digestion, Dewatering by centrifuge, Composting	Composting	2.76	Biological	NA	NA
CZECH REPUBLIC	OLOMOUC	ZLIN - MALENOVICE	207,000	40,000	Anaerobic digestion, Dewatering by belt filter, Dewatering by centrifuge	Handover to specialized company for reuse	5.17	NA	NA	NA
CZECH REPUBLIC	PLZEN	PLZEN	375,000	127,500	Anaerobic digestion, Dewatering by filter press,	recultivation of landfills		NA	Biogas recovery into energy	3 units of cogeneration - 520 Kwh Each
CZECH REPUBLIC	PRAGUE	UCOV TROJA	1,641,600	600,000	Anaerobic digestion, Dewatering by centrifuge, Composting	Composting	118	Biological	Biogas recovery into energy	Biogaz recovery of sludge digestion tanks – 4 bioreactors (1 MW each – energy recovery Energy produced / Energy consumed: 75 %
CZECH REPUBLIC	PRIBRAM RICANY	PRIBRAM	76,300	19,000	Anaerobic digestion, Dewatering by centrifuge, Compostinging	Composting	2.3	NA	NA	NA
CZECH REPUBLIC	KLADNO, MELNICK, PART OF PFRAUQE EAST AND WEST REGIONS, RKOVENI AND MLADA BOLESLAV	KRALUPY NAD VLATVOU	59,667	12,853	Anaerobic digestion, dewatering by centrifuge,	Passed to the authorized company	1.15	NA	NA	NA
CZECH REPUBLIC	KLADNO, MELNICK, PART OF PFRAUQE EAST AND WEST REGIONS, RKOVENI AND MLADA BOLESLAV	KLADNO VRAPICE	86,350	43,718	Anaerobic digestion, Dewatering by belt filter, Dewatering by centrifuge	Passed to the authorized company	2.3	NA	NA	NA
HUNGARY	BUDAPEST	PEST SUD	293,000	80,000	Static thickening Anaerobic digestion Dewatering by centrifuge	Agriculture or Landfill	15	Biological	Biogaz Recovery in Cogeneration	Cogeneration capacity: 3 MW Energy produced / energy consumed: 42 %
HUNGARY	BUDAPEST	PEST NORTH		200,000	Aerobic digestion, dewatering by filter press	Landfill	70	Biological	Biogaz recovery in cogeneration	Cogeneration capacity: 1,5 MW Energy produced / energy consumed : 67 %
HUNGARY	SZEGED	SZEGED	230,000	60,000	Anaerobic digestion Dewatering by centrifuge Composting	Composting	9.5	Biological	Biogaz Recovery in Cogeneration	2 gas engines (energy and heat)
SLOVAK REPUBLIC	BANSKA BYSTRICA REGION	BREZNO	50,000	13,220	Anaerobic digestion, dewatering by centrifuge	Composting	1	NA	NA	NA
SLOVAK REPUBLIC	BANSKA BYSTRICA REGION	LUCENEC	64,690	17,885	Anaerobic digestion, dewatering by centrifuge	Land application - Composting	1.5	NA	NA	NA
SLOVAK REPUBLIC	BANSKA BYSTRICA REGION	ZVOLEN	80,500	22,922	Anaerobic digestion, dewatering by centrifuge	Land application - Composting	2.6	NA	NA	NA
SLOVAK REPUBLIC	BANSKA BYSTRICA REGION	ZIAR NAD HRONOM	16,964	33,903	Anaerobic digestion, dewatering by belt filter	Land application - Composting	0.5	NA	NA	NA
SLOVAK REPUBLIC	POPRAD DISTRICT	SPISSKA NOVA VES	82,418	23,245	Anaerobic digestion, dewatering by centrifuge, Composting	Composting	2.7	NA	NA	NA
SLOVAK REPUBLIC	POPRAD DISTRICT	POPRAD - MATEJOVCE	143,206	46,980	Anaerobic digestion Dewatering by centrifuge Composting	Composting	3.44	NA	NA	NA
SLOVAK REPUBLIC	POPRAD DISTRICT	KEZMAROK	56,000	16,245	Anaerobic digestion, dewatering by belt filter, dewatering by drying beds, Composting	Composting	1.68	NA	NA	NA