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Selection of Wastewater Treatment Technology of the Capital of Podgorica in the New Plant

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Abstract: Podgorica the capital of Montenegro has 210,000 inhabitants. There is a well-resolved issue of water supply with quality drinking water. It is very important to mention that in 1978, Podgorica had built a wastewater treatment plant. The capacity of the built plant is 55,000 PE, which is inadequate to process already connected 119,000 PE. The capacity of the new planned plant is for 235,000 PE in 2040. The future plant will be built at a new location in the industrial zone of "KAPP" (Aluminum plant Podgorica). The new plant will be a unique system in which three plants will be built for purification of waste water, a treatment plant for the sludge in order to obtain biogas, that is, electricity and hot water, and a plant for the incineration of the sludge residue in the fluidizing layer. It is planned that the purified water-effluent that flows into the recipient-Morača River is A1 class. It is water that can be used for bathing and watering agricultural products. Taking into account that this is a sensitive area, in this way, Skadar Lake will be protected from the impact of municipal wastewater. Eliminating odors are foreseen for all three plants. It is also planned the destruction of pathogenic bacteria by UV rays. The aim of this work is to demonstrate that the optimum available technology is selected for the new plant, which will provide the maximum protection of the recipient-river Morača, the Skadar Lake as a national park and the land of the Zeta Plain.

Key words: Waste water, purification, plant.

1. Introduction

The existing WWTP (waste water treatment plant) of the capital of Podgorica was built in 1978. The capacity of the existing plant is for 55,000 PE, and the current flow of municipal wastewater and the pollution load is approximately 119,000 PE. Collection and disposal of municipal waste water are carried out in the existing sewage and are disposed to the plant, which has 100% overload. Existing technology in the old plant does not provide the quality of purified water-effluent A1 class, poorly solved disposal and sewage sludge treatment, removal of unpleasant odors, impede the urgent resolution of this important ecological problem in Podgorica. Because of the limited capacity of the existing plant, only 50% of the municipal wastewater is completely processed from the total collected and brought in municipal wastewater. The remaining quantities are brought to primary mechanical scrubbing, then discharged by the collector into the recipient river Morača. The discharge of only partially treated municipal wastewater as unprocessed effluent significantly influences the quality of the river Morača, so that after the collector for discharging the treated waters, the Morača water corresponds to the A2 and A3 class quality [1]. All of these factors are extremely important reasons for the need to build a new facility with the appropriate capacity and acceptable processing technology.

Also, the important reason for the construction of a new plant is that the existing plant and disposal of the sludge is located in the wider Podgorica area and is surrounded by residential buildings and large commercial markets that are not compatible with the above-mentioned industrial plant.

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Before making a final decision on the construction of a new plant, three studies were carried out by well-known companies involved in the design of the WWTP, which are: "SOGREAH"—France [2], Institute for waters WYG—London [3], FICHTNER—Germany [4]. All three studies have shown that an appropriate wastewater treatment plant needs to be built in Podgorica urgently and that the proposed site for new plants fully meets the criteria that must be met to build a WWTP at that location. The investor insists that the new plant must meet the following conditions:

- With the construction of modern wastewater treatment facilities it is necessary to ensure the efficiency of the purification, which the quality of the effluent is of A1 class, with the purpose of adequate protection of the Morača River, the water sources of Boljesestre, Skadar Lake and the Zets Plains;
- In line with the planned capacity of 235,000 PE, to extend the sewage network, which will enable the removal of defective sanitary facilities, primarily due to the use of septic pits;
- The planned extension of the sewerage network and the connection by the year 2040 of 116,000 PE will automatically improve the situation in all the areas in Podgorica that are not covered by the sewerage network;
- The treated sewage sludge is converted into biogas, electricity and hot water;
- To remove the unpleasant smells from all production plants and remove all pathogenic bacteria from the effluent.

2. Parameters for Designing WWTP in Podgorica

The design parameters for the dimensioning of the future WWTP Podgorica, based on the necessary design criteria, are presented in Table 1 [5].

The production of sewage sludge is estimated at 10,100 tons per year, for projected capacity of WWTP of 135,000 PE, for phase 0 through 2020. For phase 1 through 2030., projected capacity of WWTP is 187,700 PE, with annual sludge being calculated at 13,800 tons/year. For phase 2 through 2040., projected capacity of WWTP is 235,000 PE, pri čemu je godišnja with annual sludge being calculated at 17,000 tons/year.

The selected location for the new WWTP is located approximately 3 km south of Podgorica, on the left bank of the Morača River (Fig. 1) and close to the Podgorica (KAP) Aluminum Combine [6].

3. Proposed Conceptual Solution for WWTP Podgorica

Based on the study of the solution made by FICHTNER—Germany, the steps are taken that are in line with the requirements of the Investors of ViK (Water & Sewerage) Podgorica [7], in which the quality of the purified water-effluent is A1 class, to eliminate the unpleasant odors, to complete the sludge treatment in order to obtain biogas, electricity and hot water. The project took into account the minimum water flow of

Table 1 Design Parameters for dimensioning of new WWTP Podgorica.

Parameter	Unit	2016.	2020.	2030.	2040.
Population equivalent	PE	119,800	135,400	187,700	235,200
Wastewater flow on dry days	m^3/d	31.970	31.140	38.830	46.340
Wastewater flow on wet days	m^3/d	45.070	46.200	56.180	57.450
Polution load					
BPK_5	kg/d	7.189	8.122	11.263	14.109
HPK	kg/d	14.379	16.244	22.526	28.219
SS	kg/d	8.388	9.475	13.140	16.461
Concentration					
BPK_5	mg/L	225	261	290	304
HPK	mg/L	450	522	580	609
SS	mg/L	262	304	338	355

Fig. 1 Selected location for new WWTP.

the river Morača as a recipient in the period of June to October. The investor requested that the project engineer should ensure that concentrations of N (nitrogen) and P (phosphorus) in effluents meet the quality of the sensitive areas.

The selected technological solution foresees:

A. Primary purification of municipal wastewater;

B. Secondary purification of municipal waste water;

C. Tertiary treatment of municipal wastewater;

D. Advanced treatment of municipal waste water (removal of pathogenic bacteria);

E. Treatment of sewage sludge (production of biogas, electricity and hot water);

F. Sludge Drainage (thickening and volume reduction).

Based on the two-step evaluation of process and variant options, the following process technologies are considered:

- Basic solution: simultaneous or occasional denitrification (fully mixing) with EBPR (Bio-P) + CPR, with anaerobic digestion and sludge drainage, re-utilization of the digester gas to recover energy;
- Alternative solution: Process A2/O (piston flow with previously applied denitrification) with EBPR (Bio-P) + CPR, with anaerobic digestion and sludge drainage, re-utilization of digester gas to recover energy.

The overview of the adopted process options is shown in Table 2.

Simultaneous denitrification with EBPR (Bio-P) + CPR, with separate sludge digestion and drainage with re-use of gas from digesters for energy recovery as a CAS (conventional variant of active sludge), was selected as the basic solution given the simpler and more stable process biological purification (relative to A2/O)–Fig. 2.

A1: Basic proposition

- Primary purification
- Secondary purification
- Tertiary purification

Table 2 Proposed waste water treatment and sludge processing technology.

Step of the treatment	Basic solution	Alternative solution
Wastewater treatment (CAS for tertiary treatment, BNR with EBPR + CPR)	Simultaneous or occasional denitrification (fully mixing)	Bioreactor with piston displacement (nitrification) with previously applied denitrification (and Bio-P for EBPR)
Sludge tretament	Anaerobic mesophilic digestion sludge	
Purification and reuse of gas	Digestion gas recovery and purification with energy recovery through CCHP (CHP + cooling energy production)	
Sludge drainage	Thickening and sludge drainage	
Treatment of unpleasant smells	Bio-filter for plants for mechanical treatment and sewage sludge	

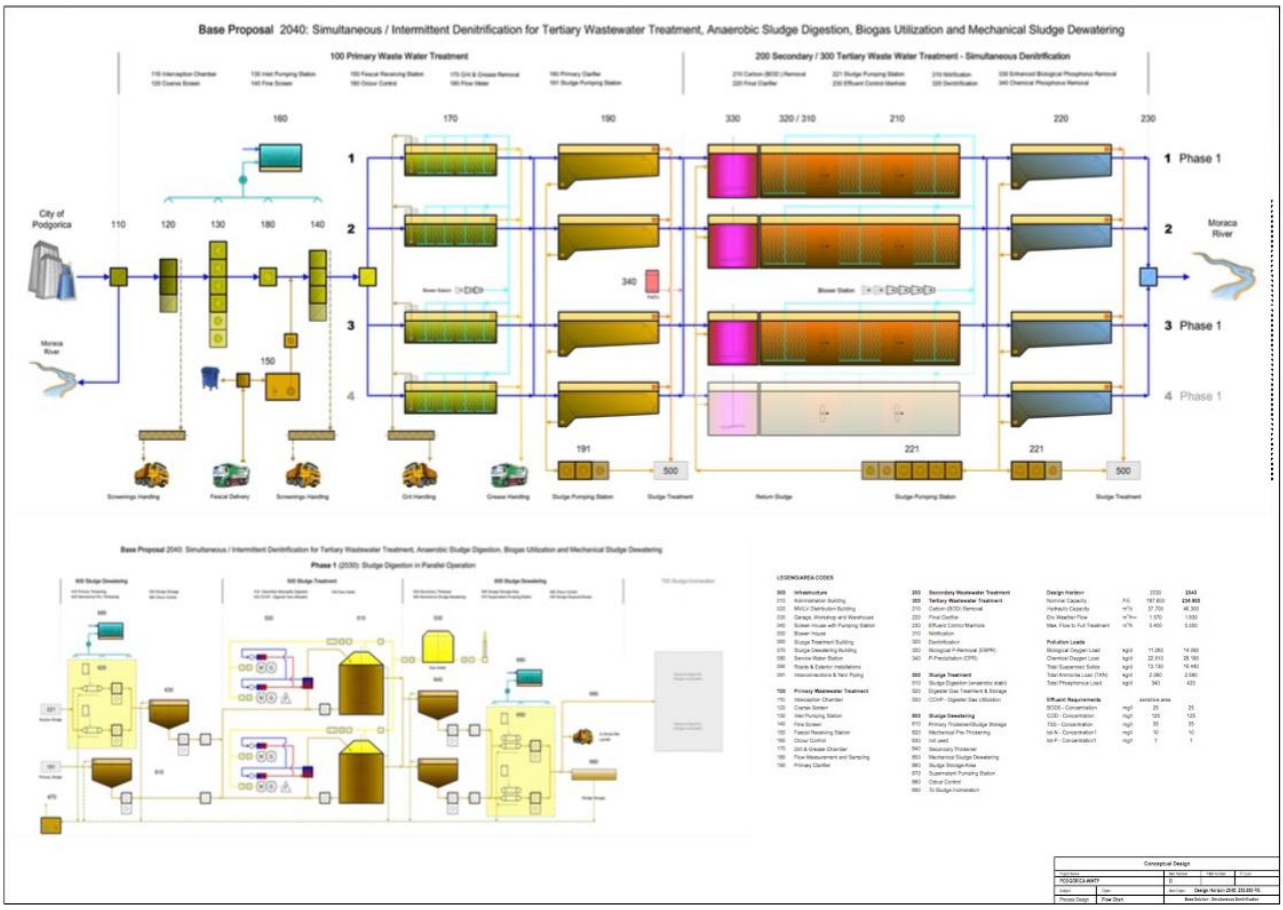

Fig. 2 The recommended process of purification of municipal wastewater in Podgorica with the preliminary solution of the sludge treatment process.

4. Simultaneous Denitrification with the Biological and Chemical Removal of P (Phosphorus) Sludge Treatment Process with Parallel and Serial Digester Operation

The drives are associated with bio-filters that help to remove and control the odor to prevent and reduce the release of the odor in the atmosphere.

The process of A2/O (piston flow with previously applied dentrification) with EBPR (BioP) + CPR, with separate digestion and sludge drainage with re-use of digestor gas for energy recovery is considered as a variant and potential modification of the process for future upgrading of WWTP.

The variation to the process of the alternative solution is related to a bioreactor project for secondary

and tertiary waste water treatment, which includes special sections for previously applied denitrification and piston-centrifuging pool for nitrification. All other process units remain unchanged.

Sewage treatment plants in the new WWTP Podgorica include the following most important steps of the process:

- Mechanical wastewater treatment, including pumping stations;
- Secondary treatment; and
- Tertiary wastewater treatment, including sludge transport.

The plants are connected with biofilters used for removing and controlling odors to prevent and reduce the release of unpleasant odor in the atmosphere.

5. Conclusions

Based on the analysis of the above-mentioned alternative of purification, it is recommended as the most productive process technology for the implementation of WWTP Podgorica:

(1) Option A1: simultaneous denitrification with separate septic digestion

(2) Option A2: previously applied denitrification (A2/O) with separate digestion of sludge

The proposed extended convencional process for wastewater treatment and sludge processing (A1) has the following advantages:

- Represents the generally accepted process with rich experience throughout Europe;
- Provides the quality of purified water-Fluorine A1 class, which can be used for bathing and pouring agricultural products; the total nitrogen concentration of TN is ≤ 10mg/L, the total phosphorus TP is ≤ 1 mg/L and TSS ≤ 35 mg/L;
- Provides an increased volume of bioreactors (about 20%) and protective (bafer) capacity (from load oscillation) compared to A2;
- There is a reduced number of operating and service points (no internal recirculation pumps);
- There is a limited need for instruments and simple process control (DO/Redox);
- Provides the possibility of future modification of the wastewater treatment process, i.e. transformation into A2/O or step-feed-process with appropriate purification capacity reserve;
- Provides the possibility of future modification of the sludge processing, i.e. switch from parallel to serial digester operation with the appropriate reservoir capacity reserve.

The construction of WWTP Podgorica will have a positive impact on:

- Local water resources, the Morača river, the Skadar Lake National Park and the Zeta Plain;
- General health of the population (elimination of diseases related to untreated waste water).

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