ROYAL HASKONING

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DELOITTE&TOUCHE CENTRAL EUROPE

ANNEX 3.13:

TECHNICAL DESCRIPTION OF THREE EVALUATED WWTP LESKOVAC

13 December 2007
Municipal Infrastructure Agency Support Programme
An EU-funded project managed by the European Agency for Reconstruction
9R5927/CvS/R2006_21/R001
Feasibility Study Leskovac
Final Report

Alternative A: conventional low loaded activated sludge, aerobic and mechanical sludge treatment is comprised of the following elements per process line:

The **water line** is comprised of:

Primary (mechanical) treatment

- coarse screening for removal of coarse floating debris and waste;
- pumping station to automatic fine screens;
- automatic fine screens for the removal of finer floating debris;
- aerated sand and grit chamber for the removal of sand, grit and oil and fat;
- primary sedimentation for settling of suspended and colloidal matter in rectangular basins.

Secondary (biological) treatment

- biological (activated sludge) treatment for the removal of organic matter and nitrification of ammonia by means of intensive submerged (diffused) aeration in rectangular basins;
- secondary sedimentation for sludge settling and recirculation in circular basins;
- sludge recirculation and excess sludge withdrawal;
- UV disinfection of effluent prior to discharge;
- flow measurement between aerated grit removal unit and primary sedimentation unit and after UV disinfection prior to discharge, by means of ultrasonic devices.

The **sludge line** is comprised of:

- chemicals (polyelectrolyte) conditioning of excess sludge;
- preliminary thickening by means of centrifuge;
- common thickening of primary sludge from the primary sedimentation and centrifuged excess activated sludge;
- common chemicals (polyelectrolyte) conditioning of thickened primary sludge and centrifuged excess activated sludge;
- dewatering of conditioned sludge by means of centrifuge;
- collection and disposal of dewatered sludge cake (to solid waste disposal site, reuse in agriculture or landfill);
- recycle of clarified and seeped water from sludge thickening process back to process inlet.

The **air line** is comprised of low pressure air supply necessary for the operation of:

- the aerated sand and grit removal unit;
- the aerobic sludge stabilisation;
- the aeration basin for provision of oxygen and mixing of biomass.

The **chemicals line** is comprised of:

- storage, preparation and dosing equipment for polyelectrolyte for sludge conditioning prior to centrifuges.

The conventional activated sludge treatment is based on primary sedimentation followed by activated sludge treatment in rectangular basins with plug flow conditions. Aeration is by means of compressed air aeration through membrane diffusers. In the activated sludge basins biological decomposition of organic matter takes place. Horizontal mixing facilities are included in these tanks to enable/ascertain plug flow conditions. The mix of activated sludge and water is further led to circular secondary sedimentation basins to separate and partially return sludge into the activated sludge basins and to dispose of excess sludge quantities. Supernatant water from the secondary sedimentation is disposed into the receiving water body with prior UV disinfection.

Excess sludge is conditioned by means of polyelectrolyte and reduced in quantity by means of centrifuging. Together with primary sedimentation sludge excess sludge is then transported to a circular basin for aerobic sludge stabilisation by means of air blowers. Stabilised sludge is transported to a circular gravitational thickener for further thickening. Here the sand and oil and fat from the aerated grit chamber are also collected. The supernatant is recycled while the sludge is further conditioned by polyelectrolyte and centrifuged for dewatering, prior to an approved disposal site.

The WWTP has been conceptualised in a way that it makes it possible to upgrade the WWTP to achieve additional removal of phosphorous and nitrogen. The upgrade of the plant is envisioned by means of preliminary denitrification in (anoxic) basins prior to the aeration basins, with the provision to recycle water and sludge from the aeration basin to these basins. Corresponding provision of the necessary footprint area has been made in the design.

Therefore, in order to achieve the effluent criteria with regard to nutrient removal as defined earlier, it would be necessary to extend the plant by introduction of additional process components.

It is possible to achieve phosphorus removal simultaneously with nitrogen removal by intermittent exposure to oxic and anoxic conditions. Considering the wide range of wastewater P concentration (2.4 -11.4 mg P/l) it is likely that periodically additional phosphorus removal will be required to comply with the EU discharge norms. This can be achieved e.g. by means of chemical precipitation (e.g. by means of $FeCl_3$ coagulation and flocculation).
The required plant footprint for this alternative is 2.7 ha.

Alternative A Conventional low loaded activated sludge and aerobic mechanical sludge treatment is well established and practically proven technology in the capacity range of the project.

Benefits of this alternative are:

- Well established technology with largest number of references, including existing local operational WWTPs;
- Phased approach to (investment and) achieving effluent standards possible;
- Reliable and robust technology;
- Stable effluent quality under varied capacities and quality of wastewater.

The drawbacks of this alternative are:

- Presumably, slightly higher investment and operational costs of all analysed alternatives;
- Largest footprint requirement (not of crucial importance considering availability of land and relatively low costs);
- Complex technology with large number of units and complex equipment;
- Largest labour requirements.

Comments:

- *The stated drawback regarding higher investment and operational costs of this technology relative to the other considered technologies is doubtful considering the established deviations/differences of costs in practice.*
- *The stated drawback regarding complexity of technology and highest number of units and complex equipment is also contradictory, since this technology is the only of considered alternatives that is locally applied and substantial O&M experience is available.*
- *To the listed benefits should be added that, should this type of the WWTP be supplemented by a sludge digestion and power generation, a possibility to introduce power generation/recovery from sludge.*

Alternative B: Sequencing Batch Reactor plant, with continuous inflow, aerobic and mechanical sludge treatment is comprised of the following elements per process line:

The **water line** is comprised of:

Primary (mechanical) treatment

- coarse screening for the removal of coarse floating debris and waste;
- pumping stage to automatic fine screens;
- automatic fine screens for the removal of finer floating debris;
- aerated sand and grit chamber for the removal of sand, grit and oil and fat;
- primary sedimentation for settling of suspended and colloidal matter in rectangular basins.

Secondary (biological) treatment

- biological oxidation (aeration by means of membrane diffusers), sedimentation and decantation in continuously loaded SBR (Sequencing Batch reactor) basins; SBR comprised of pre-reaction chamber (10-15% of total unit volume) and reaction chamber;
- excess sludge withdrawal by means of centrifugal sludge pumps;
- flow measurement between aerated grit removal unit and SBR treatment and after UV disinfection prior to discharge, by means of ultrasonic devices.

The **sludge line** is comprised of:

- chemicals (polyelectrolyte) conditioning of excess sludge;
- preliminary thickening by means of centrifuge;
- common thickening of primary sludge from the primary sedimentation and centrifuged excess activated sludge;
- common chemicals (polyelectrolyte) conditioning of thickened primary sludge and centrifuged excess activated sludge;
- dewatering of conditioned sludge by means of centrifuge;
- collection and disposal of dewatered sludge cake (to solid waste disposal site, reuse in agriculture or landfill);
- recycle of clarified and seepage water from sludge thickening process back to process inlet.

The **air line** is comprised of low pressure air supply necessary for the operation of:

- aerated sand and grit removal unit;
- SBR reactor unit;
- aerobic sludge stabilization.

The **chemicals line** is comprised of:

- storage, preparation and dosing equipment for polyelectrolyte for sludge conditioning prior to centrifuges.

This technology is able to achieve the following effluent concentrations of specific parameters:

- BOD_5 $\leq$ 20 mg/l;
- SS $\leq$ 30mg/l;
- NH_3-N $\leq$ 2.5 mg/l.

The analysed SBR ICEAS technology is patented by the American ITT Corporation. It is characterised by continuous inflow of wastewater in a pre-reaction chamber without primary sedimentation. In the pre-reaction chamber, which is approximately 10-15% of the total volume of the SBR reactor, wastewater is brought from above and faces counter current aeration introduced at the bottom of the tank. The aeration enables 70-80% BOD degradation/adsorption in the pre-reaction chamber. This basin also serves as selector for organic matter and prevents the formation of filamentous bacteria common for the conventional activated sludge process. After this step the water enters the reaction chamber where intensive aeration is applied by means of fine bubble aeration with diffusers. When the maximum water level in the reaction chamber is achieved, the air supply is automatically stopped (PLC). Settling of flocculated sludge takes place and clarified water remains as supernatant. After a pre-set settling time an overflow weir is activated and lowered to accept supernatant water up to a pre determined level. After the supernatant is disposed the process is repeated. Supernatant water is disposed of with prior UV disinfection. Sludge is disposed periodically in time intervals depending on design. The duration of specific phases with and without air supply is pre-determined based on the quantity and quality of treated wastewater. The process can be fully automated and is largely dependant on functioning of process control equipment.

Achievable BOD_5 and SS concentrations are in line with the pursued EU norms. Based on the achievable NH_3-N concentration of $\leq$ 2.5 mg/l it may be presumed that the total N concentration will be in line with the EU norm of <15 mg N/l (for settlements with 10.000 - 100.000 inhabitants). Furthermore, the concentration peaks of P in the wastewater imply that it is very likely that periodically additional removal of phosphorus by chemicals dosing (e.g. $FeCl_3$) may be required. Based on the available information it is deduced that additional phosphorus removal has not been considered in the project design and cost calculations.

Excess sludge is conditioned by means of polyelectrolyte and reduced in quantity by means of centrifuging. Centrifuged sludge is then transported to a circular basin for aerobic sludge stabilisation by means of air blowers. Stabilised sludge is transported to a circular gravitational thickener for further thickening. Here the sand and oil and fat from the aerated grit chamber are also collected. The supernatant is recycled while the sludge is further conditioned by polyelectrolyte and centrifuged for dewatering, prior to an approved disposal site.

The required plant footprint for this alternative is not specified. Figures from practice imply a footprint area approximately 30% lower than required for the conventional plant. A footprint of circa 2 ha is assumed necessary for further analysis.

Alternative B: Sequencing Batch Reactor plant, with continuous inflow and aerobic mechanical sludge treatment is a patented and advanced version of the well established and proven SBR technology. SBR technology is most frequently applied for smaller plants (<50.000 PE). Technological developments led to substantial increase of unit capacities in the region well beyond the capacity of the Leskovac WWTP. SBR plants of the proposed ICEAS type are operated in practice at capacities of up to 500.000 m3/day.

Benefits of this alternative are:

- Compact technology with lowest number of water line related units;
- Fast and efficient accommodation to fluctuations in water quality and quantity;
- Low labour requirements;
- No sludge recirculation required.

The drawbacks of this alternative are:

- Largest quantity of resulting biological sludge;
- Complex equipment and system regulation;
- Reliability on constant/undisturbed electricity supply;
- Sensitivity of PLC system to variations/instability in the electricity transmission system;
- Economical considerations limiting technology application preferably for capacities <30.000 PE.

Comments:

- *The stated drawback regarding limitations of the technology to capacities <30.000 inhabitants is not correct, since the ICEAS process is economically feasible for installations of up to 500.000 m3/day.*

Alternative C: modified low loaded activated sludge treatment type A2O with aerobic and mechanical sludge treatment is comprised of the following elements per process line:

The **water line** is comprised of:

Primary (mechanical) treatment

- coarse screening for the removal of coarse floating debris and waste;
- pumping stage to automatic fine screens;
- automatic fine screens for the removal of finer floating debris;
- aerated sand and grit chamber for the removal of sand, grit and oil and fat;
- dosing of $FeCl_3$ for the chemical precipitation of phosphorus;
- biological (activated sludge) treatment for the removal of organic matter in circular basins; activated sludge basin partitioned in anoxic and anaerobic zone positioned in the central (slowly mixed) part of the basin and aerobic and anoxic peripheral circular (slowly mixed) channels with fine bubbles aeration by means of submerged diffusers;
- degassing of the effluent from the biological treatment for nitrogen gas removal;
- secondary sedimentation for sludge settling and recirculation in circular basins;
- sludge recirculation and excess sludge withdrawal;
- flow measurement between aerated grit removal unit and the biological treatment unit and after UV disinfection prior to discharge, by means of ultrasonic devices.

The **sludge line** is comprised of:

- chemicals (polyelectrolyte) conditioning of excess sludge;
- sludge thickening by means of belt gravity thickener;
- dewatering of conditioned sludge by means of a filter belt press;
- stabilisation of dewatered sludge by means of lime (CaO) dosing;
- collection and disposal of dewatered sludge cake (to solid waste disposal site, reuse in agriculture or landfill);
- recycling of clarified and seepage water from sludge thickening process back to process inlet.

The **air line** is comprised of low pressure air supply necessary for the operation of:

- aerated sand and grit removal unit;
- aerated biological basin for provision of oxygen.

The **air treatment line** is comprised of:

- biological filtration of odorous air collected from covered/isolated treatment units emitting objectionable odours (the ALIZAIR® process of Veolia Water Systems based on the use of mineral adsorption material BIODEGANE®).

The **chemicals line** is characteristic for the:

Water line

- storage, preparation and dosing equipment for $FeCl_3$ dosing in the central anaerobic part of the biological treatment basin for enhanced phosphorus precipitation.

Sludge handling line

- storage, preparation and dosing equipment for cationic polyelectrolyte for sludge conditioning prior to filter belt press.

The proposed treatment process is known commercially as AZENIT P® process and is a patent of Veolia Water Systems. The process is similar to the Orbal® and Bionutre® processes, that are based on intermittent aeration in oxidation ditch like structures, thus enabling the formation of anoxic/aerobic zones and nutrient removal. The AZENIT P® process enables anaerobic/anoxic/aerobic circumstances in one unit, thus enabling nitrification/denitrification and phosphorus removal. No specific figures from practice are given regarding the efficiency of this patented process from similar projects elsewhere. It is presumed that the pursued EU norms can be achieved.

Primary sedimentation is omitted in this process. The activated sludge basin is partitioned in two zones:

- anoxic and anaerobic zone in the centre of the basin with mixing facilities and without aeration;
- aerobic and anoxic channels with slow mixing and aeration by means of fine bubble aeration (diffusers).

In the first anoxic/anaerobic zone partial denitrification and phosphorus release takes place. The anoxic zone precedes the anaerobic one and guarantees fully anaerobic conditions that stimulate phosphorus release. The anoxic/aerobic zone is the peripheral; part of the circular basins and functions on the oxidation ditch principle. Prolonged aeration is applied with sufficient travelling time in the ditch to enable nitrification and denitrification in the anoxic zone. Full phosphorus removal is enabled by means of $FeCl_3$ dosing in the central anaerobic part of the basin.

Treated water and sludge from these basins is further led to a degassing unit that removes the elementary nitrogen gas released during denitrification; this in order to avoid flotation in the secondary sedimentation basins that follow as a next treatment step. Clarified water from the secondary sedimentation is disinfected by means of UV prior to discharge.

Excess sludge from the biological treatment is led to a gravitational belt thickener. Polyelectrolyte is used for conditioning of the sludge, prior to a filter belt press dewatering and thickening unit. Thickened sludge is stabilised by means of lime (CaO) dosing, prior to disposal to an approved disposal site.

The process includes odour control by means of transporting collected (ventilated) air from critical units to a patented air treatment unit (the ALIZAIR® process of Veolia Water Systems based on the use of mineral filling adsorption material BIODEGANE®). The required footprint for this alternative is 2.2 ha.

Alternative C: modified low loaded activated sludge treatment type AZENIT P® with aerobic mechanical sludge treatment is a patented version of biological water treatment with integrated nitrogen and phosphorus removal in one unit. A limited number of such units have been constructed in the past 10 years, mostly in France and neighbouring Belgium. Examples include Brussels North (558.000 m^3/day constructed in 2007), Rouen (85.000 m^3/day constructed in 1997) and Lourdes (25.000 m^3/day constructed in 2004).

Benefits of this alternative are:

- Compact installation with a smaller footprint than the conventional treatment;
- Fast and efficient accommodation to fluctuations in water quality and quantity;
- High efficiency for N and P removal due to sequential aeration within a small area and a constant effluent quality;
- Reasonable consumption of chemicals and electrical energy;
- Relatively lowest gases, odour and noise emissions compared to the other technologies;
- Low labour requirements;
- Relatively lowest investments.

The drawbacks of this alternative are:

- Limited number of practical applications;
- Lack of local experience with the technology;
- Complex equipment and system regulation;
- Dependant on continuous and reliable functioning of process regulation equipment.

Figure 1 WTP Leskovac; Process flow diagram of the A_2O-type plant

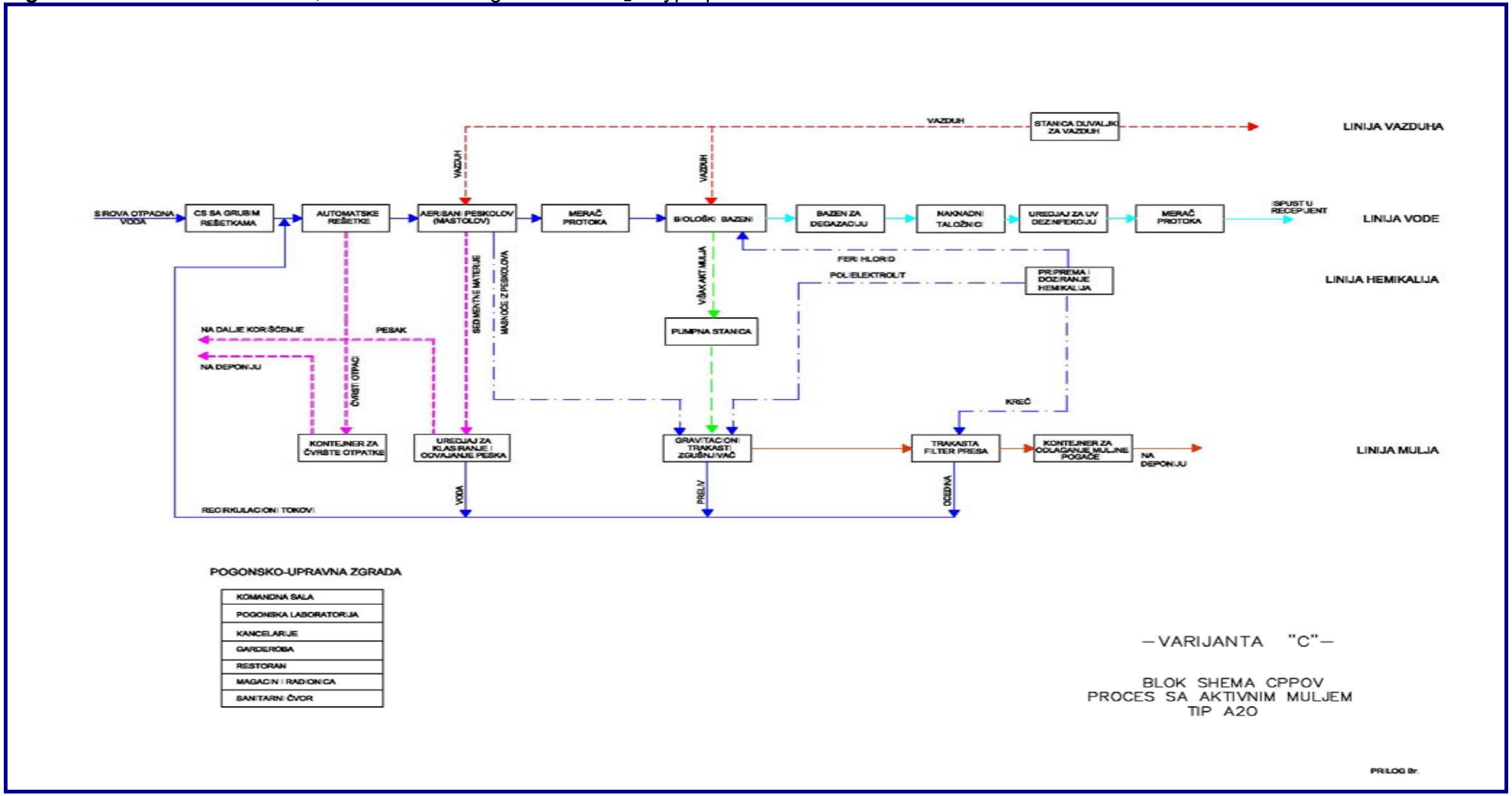

Figure 2 WTP Leskovac; A_2O-type plant general layout