History of Budapest Sanitation and Wastewater Treatment

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Abstract

Buda and Pest settlements were unified to Budapest capital city in 1873 which city was the cradle of the modern sanitation of Hungary. In the middle of the 19th century, the sanitation in many foreign cities was begun, and London provided the sample for Hungary, because its pioneer Public Health Act was become to an example throughout Europe.

The sanitation plan of the Capital city went through many modification, meanwhile the wastewater treatment was not an issue in the beginning. According to the Danube protection against the wastewater and other diseases, four wastewater treatment plants were designed in concept level. Finally the planned concept were changed and now all wastewater of Budapest is treated by three large municipal wastewater treatment plants in compliance with the European Union limits.

1. Introduction

Budapest, the capital city of Hungary, is situated in the middle of the Danube basin surrounded with Carpathians. The city area is 525 km^2, its inhabitants number is 1.75 million capita (Figure 1).

The previously of the city history was the three settlements merger along the Danube: Óbuda, Buda (German name was Ofen) and Pest in 1873 (Figure 2). It can be seen that a Danubian stream served the surface water collection at the Pest side, which was refilled by the fabulous urban engineer, Ferenc Reitter in the last third of the XIXth century. From this emerged the present-day "Grand Boulevard", in which a storm water collection channel with diameter 5 m was built. Now this channel is one of the most important element of the Pest sewerage system.

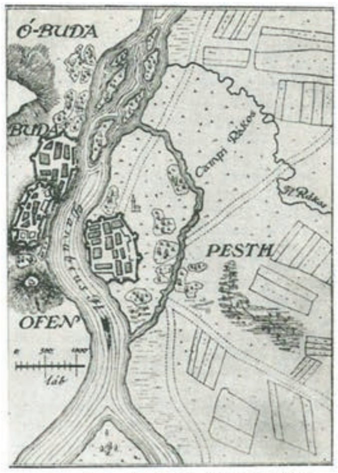
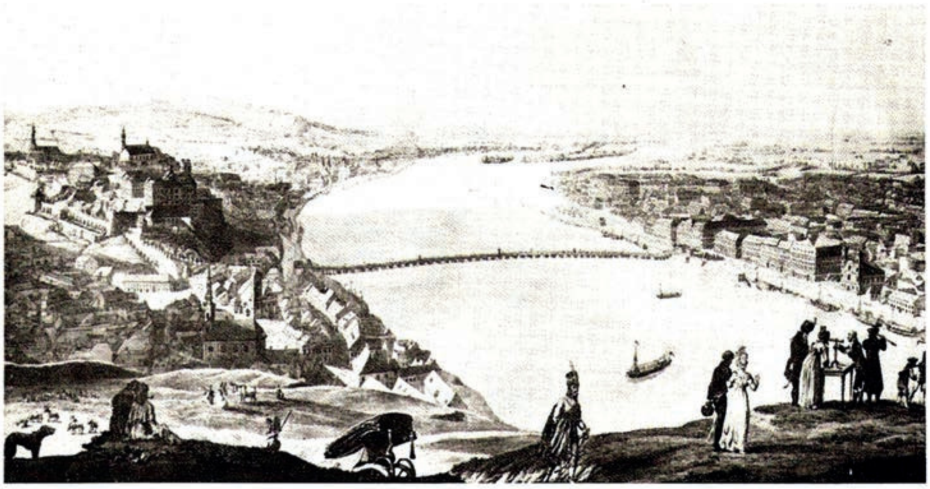


Figure 2: The three settlements at the bank of Danube in 1873 (Garami, 1972).

One picture can sketch the slowly increasing metropolis, situated in the two sides of the Danube (Figure 3).

Figure 1: Situation of Budapest (Wikimedia).



Buda és Pest látképe a XIX. sz. elején. A budapesti Történeti Múzeum gyűjteményéből

Figure 3: The city view at the beginning of the century XIX (Garami, 1972).

In the Roman age the booming Aquincum was in the neighbourhood of **Óbuda** with 6 000 people military camp and belonging civil city area, which was built with sanitary and storm water collection system, and an aquaduct served the hot water. (The remained ancient ruins are popular tourist visiting destination.)

Buda is a suburban area which is located among gentle hills. The Royal Castle from the age of Matthias King was an outstanding cultural centre its own time and now as well, and since it is considered watchful eye on the rapidly developing modern city.

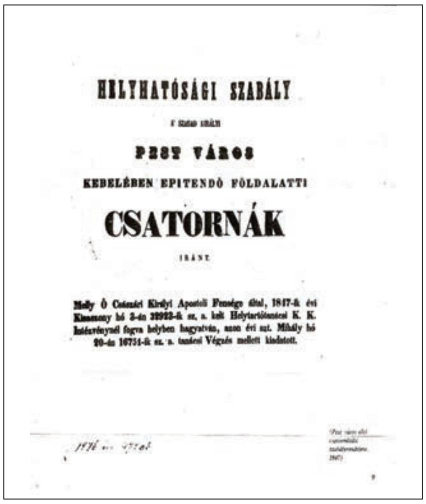
The high-walled **Pest** represented the frequented area for the traders and the skilled crafts. All area had channels without any operating system which mainly served the rainwater collection, and trying to find the shortest path to the Danube River or any other streams. Into this open channel, naturally, the wastewater was led as well (Figure 4).

Figure 4: The wastewater collection in barrels in the century XVII-XVIII (Juhász, 2008).

London served as a sample to Hungary, because its pioneer Public Health Act was become to an example throughout Europe.

The fear from the epidemics which decimated the large cities population like plague, typhus, cholera, and the industrialization, the demand of the higher comfort as well as the increased population required the implementation of the sewerage construction in the capital city.

However the sewerage system construction has been taken, the "Municipal Regulation" related to the sewerage was published in 1847 (Figure 5). The cost of the War of Independence in 1848 postponed all other investment for a long time. The question of the modern sanitation appeared on the agenda after twenty years.



HELYHATÓSÁGI SZABÁLY

PEST VÁROS

KEBELÉBEN EPITENDŐ FÖLDALATTI

CSATORNÁK

IRÁNT

Figure 5: The Municipal Regulation about the sewerage in 1847 (Juhász, 2008).

2. The beginning of the modern sanitation

The cradle of the Hungarian modern sanitation was the Capital city established from the already mentioned three settlements. In the middle of the XIXth century the sanitation of many foreign metropolis had already begun, among which

In the second third part of this century the sanitation has become to the cardinal issue of the public health-science, and János Fodor professor of medicine was the outstanding forerunner of this tendency. He was the innovator of the implementation of the conscious and system-established modern sanitation. In the last part of this century it was discussed after a long debate that not only in

Figure 6: Budapest first sanitation plan made by Ferenc Reitter in 1869 (Juhász, 2008).

Budapest, but in the other parts of the country the floating sewerage system had to be applied.

In 1869 the first sanitation plans of **Pest** have already included combined sewerage system (called in today's terminology) which made by Ferenc Reitter (Figure 6). However, the existing trenches of the hilly Buda territory joined directly into the Danube, and it was not even a part of this sanitation plan. The inlets without sluice gates could cause backflows with inducing huge damage in terms of flood on both sides, which gates liquidation was done through the imposing river wall construction. The Figure 6 shows the inlets to the river as well. (At the side of Buda the liquidation of the direct untreated inlets was done almost 140 years later.)

The plans by Reitter forecasted to 500 000 population of Budapest, and the specific wastewater discharge was envisaged in 160 L capita^{-1}. After a long discussion term the modified Bazagatte English engineer's sanitation plan finally was accepted, and the development of the details was entrusted to Ottó Martin Hungarian designer after tendering. In 1892 the first construction steps were started, and the designed construction at the side of Pest was finished in 1910. At this time the planning of Óbuda, Újpest and other suburbs took place. The plans of main collection channels in Újpest have already done in 1880, but the implementation have been completed after the turn of the century.

The Figure 7 shows some cross sections as a sample made by masonry stone can be seen well. Parallel with the previous case, the Óbuda main collection channels plans was begun in the last decade of the century and the implementation was started. The construction work was hampered along the sewerage by the found cemetery finds from the Avar times. The exploring of a riding warriors remains can be interesting, where they were buried with their horse clearly (Figure 8).

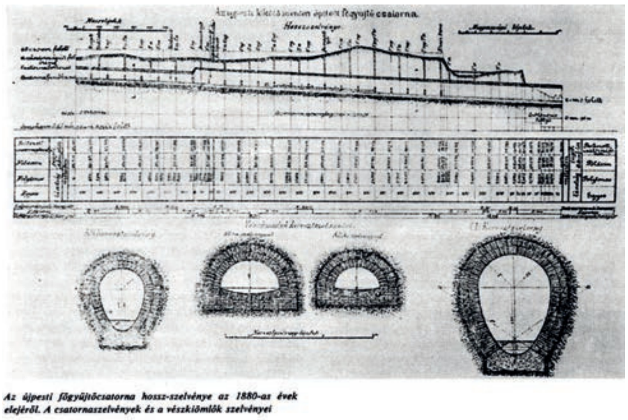


Figure 7: The plans of the main collection channels made by masonry stone in 1880 (Garami, 1972).

Figure 8: The remains of a riding warriors at the construction work in the century III (Garami, 1972).

At that time the basement of the implementation was the hand-excavation. The work ditch had to fit for the horse-drawn carriage which was used for the material handling (Figure 9).

Figure 9: The work ditch which was fitted for the horse-drawn carriage in 1910 (Juhász, 2008).

For the pipes construction very different equipment was built according to the materials of this age, the hydraulic demands and the local makings and possibilities. The oldest masonry sewerages were changed to concrete structures, then at the recent years to the different quality plastic pipes. The Figure 10 shows the built sewerage cross sections into the Capital city system, which has circle-, egg-, semi-circular, Paris-type and half Paris-type cross sections.

On the Figure 11 a masonry sewerage cross section made by brick can be seen on the left side and an interesting solution reflects in the creation of two superimposed channels on the right side.

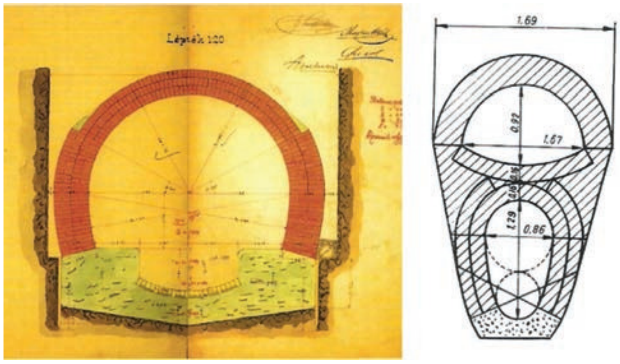


Figure 11: Masonry cross section made by brick (left) and two superimposed channels (right) (Juhász, 2008).

From the end of XIXth century, with the exception of the years during and immediately after the 2nd World War, the development of the sanitary system has been taking until nowadays. Beside the pipe materials modification, the change also manifested after 1945 that the separated systems were built in the suburban, which formed by the connection of the outskirt settlements.

The pump station houses were belonged naturally to the linear sewerage facility, which stations served the inlet of the wastewater and storm water into the recipient. The Figure 12 and 13 represent the construction of the steam driven pump station in Ferencváros at the bank of Danube in 1892. This station, after many reconstructions and modernization, is the central facility of the Budapest Sewage Works in the recent days. The begun development was halted by the 1st World War, but shortly afterwards the connections of the other parts of the city were started as well.

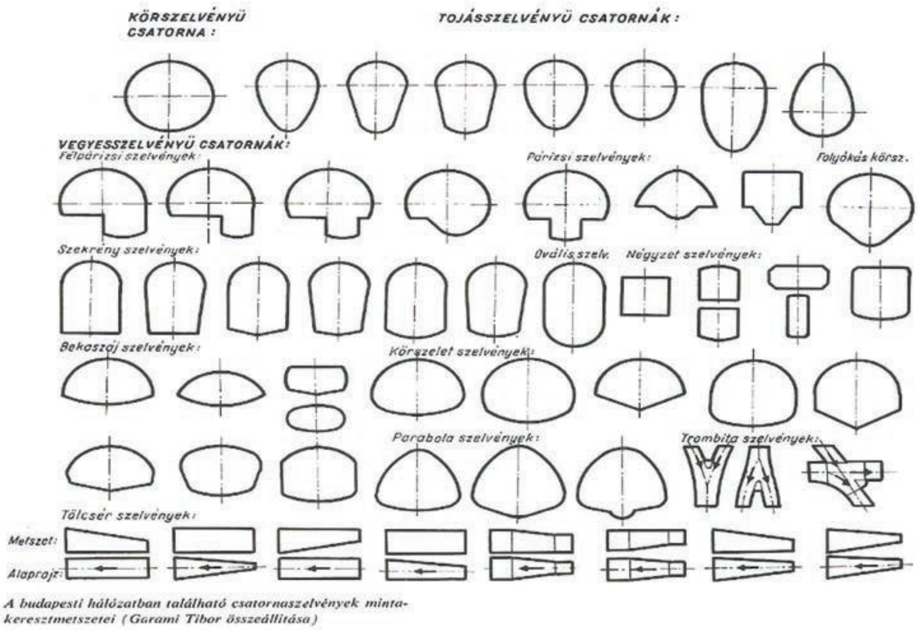


Figure 10: Typical sewerage cross sections built into the Budapest sewerage system (Garami, 1972).

Figure 12: The installation of the pump station in 1890-1894 (Juhász, 2008).

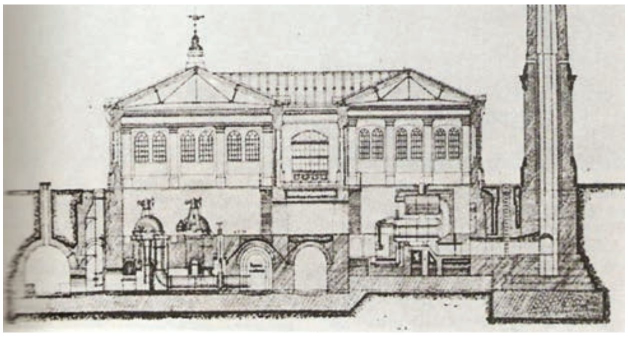


Figure 13: The pump station house in 1894 (Garami, 1972).

3. The necessity of the wastewater treatment was not the central issue…

In the first third of the XXth century the wastewater treatment was out of question. Next to the economic causes, the main reason from the decision-makers was that the almost 200 times dilution of the Danube abounding in water does not necessitate the intervention, on the other hand "with this treatment the nutrients were withdrawn from the aquatic life". This principle reflected in the founding letter of the Sewerage Company, but the wastewater treatment was not mentioned.

The sanitation and the wastewater treatment was not a part in the upper education. The Hungarian engineers have acquired the knowledge by working next to the foreign – mainly German and English – engineers. Only after the end of 1930s some young students could get out to Swiss or German University and study the profession.

To hold back the contamination the practical knowledge spread up to the level of the screens-grit tanks-primary settling tanks. The appearance of the wastewater treatment emerged in aspect of the drinking water wells of Budapest. For this purpose in 1936 with 30 km far to North from Budapest, a two-storey sedimentation tank was built for Vác city, which efficient was cca. 20 % in aspect of the suspended solids removal, and cca. 8 % in aspect of organic materials removal.

In 1936 at North periphery of Budapest, namely Angyalföld (today District XIII), a mechanical stage plant (screens, grit tanks and primary settling tanks) was designed before one of the Danubian storm water inlet pumping stations (Figure 14).

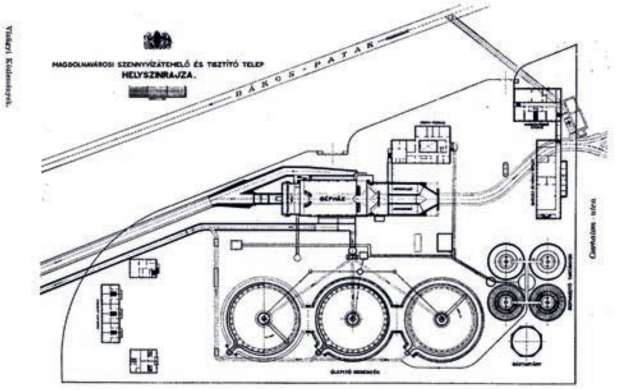


Figure 14: The plan of the Angyalföld mechanical treatment plant in 1936 (Juhász, 2008).

Nevertheless the engine house was built, the construction of the plant was "washed away" by the preparation for the 2nd World War. At this time in order to getting biogas three so-called screenings digester tanks were built at the already mentioned pump station in Ferencváros. Unfortunately, the operation was not efficient because of deficiency of sufficient organic matter, therefore in some years later this plant was demolished (Figure 15).

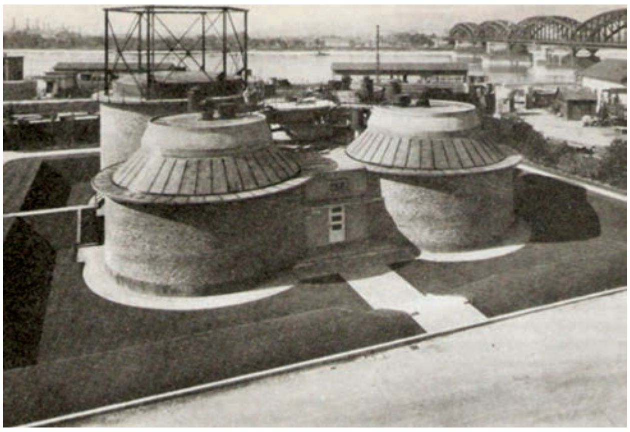


Figure 15: View of the screenings digester tanks in Ferencváros in 1936 (Garami, 1972).

4. The reconstruction and new approach…

At the end of the War, the continuously bombing and the months-long siege of the Capital city caused enormous damage in the sewerage system. The shots by the bombing and the shelling induced more than 500 collapses, pump stations fell into decay (Figure 16).

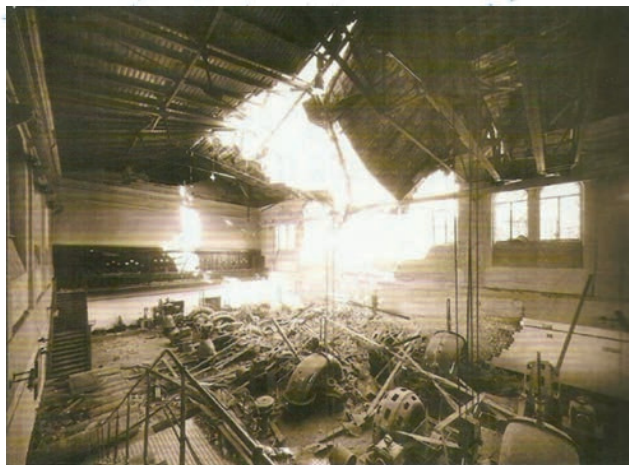
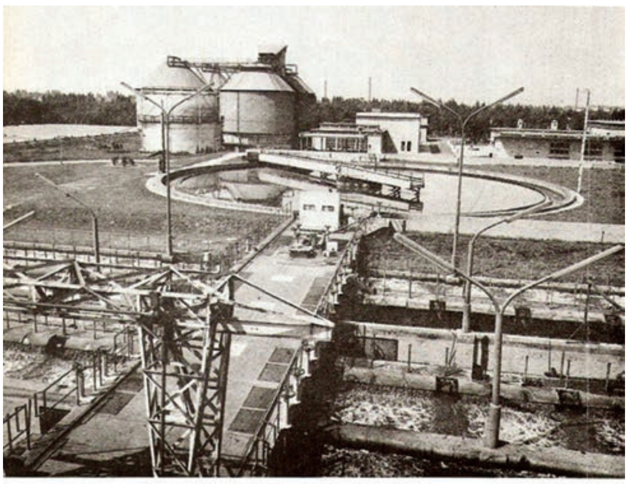


Figure 16: War damage at the pump station (1944-1945) (Juhász, 2008).

For some years after the War the economic strength was engaged by the reconstruction tasks. The sanitation unfolding was retarded by not only the system reconstruction, but the reorganization of the operator organization itself as well.

In terms of numbers, typically before the 1st World War (until 1914) the already built sewerage length was 80 km. For the periods of 1915 – 1945 and 1945 – 1949 the constructed channel lengths were 266 km and 13 km, respectively.

In point of wastewater treatment it was popular knowledge for a long time that the Danube can treat the contaminants. Due to the influx of the European developments news the effective treatment of the wastewater of the South industrial areas was decided. The plan was very modern activated sludge system compared to then. To get the knowledge of the new technology and experience an experimental activated sludge plant (800 m^3 d^{-1}) was built with Kessener brush in the border of Budapest (in Pest-Szentlőrinc), which served as a basis of the implementation of first phase of South-Budapest, in perspective 3 x 36 000 m^3 d^{-1} capacity wastewater treatment plant (WWTP). Finally in 1965, after clearing greater or lesser problems the plant was installed (Figure 17). In Hungarian relation it was novelty that four mesophilic digesters were constructed for the sludge treatment.



A dél-pesti szennyvíztisztító telep. A kép hátterében a négy iszaprothasztó torony látható. Tőlük jobbra a gépház épülettömbje, balra az iszapszikkasztó ágyak. A tornyok előtt a telt gázharang (Fotó: ifj. Mészáros András)

Figure 17: The first activated sludge WWTP: South-Budapest in 1965 (36 000 m^3 d^{-1}) (Juhász, 2008).

5. New development conception was made...

In 1974 "The program of the sanitary and wastewater treatment of the Capital city" was born, which contained subcatchments based on four WWTP. The quantity of wastewater was envisaged to 2.45 million m^3 d-1 for all the four WWTP with the inlet of the agglomeration wastewater.

The occurred substantial decrease of water consumption after the political regime change required the complete revaluation of the previous concepts. After the millennium according to the new situation, new conceptions were developed which was only limited to three WWTP with the extension of the subcatchment borders. The quality and quantity loading parameters of the WWTPs were changed as well (Figure 18).

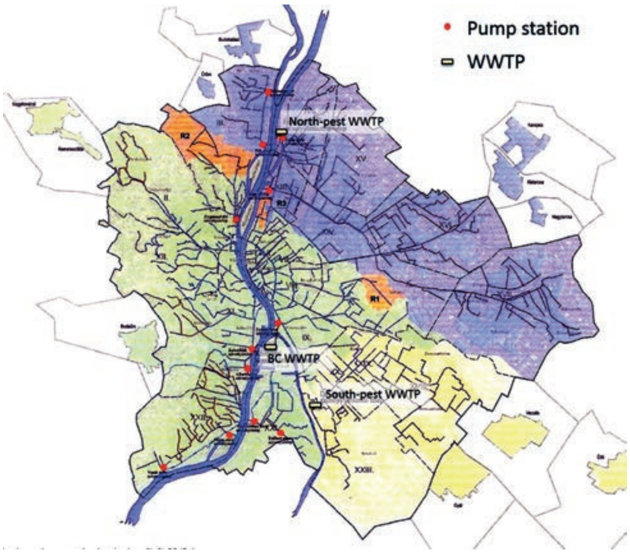


Figure 18: Three sewerage system subcatchments of Budapest with the pump stations in 2008 (Brochure).

The already operative **South-pest WWTP** (SP WWTP) was expanded to 393 000 PE (80 000 m^3 d^{-1}) after several modernization from 2005. Therefore, the deep air blowing was preferred instead of the surface aeration, and electrical and thermal energy was gained from the ~8 000 m^3 d^{-1} biogas made by 4 x 2 650 m^3 mesophilic and 2 000 m^3 thermophilic digesters. Further unique feature was that the communal organic waste was taken to the thermophilic reactor to produce significant biogas surplus and due to the gas engines electrical and heat energy gained with the so-called co-digestion, from which the 90 % energy demand of the SP WWTP can be covered. The recipient Danube branch needs restricted treating efficiency, of which the WWTP complies in all respects (Figure 19).

Figure 19: South-pest WWTP in 2003 (Brochure).

Because of the city growing, appearance of the new housing estates, the textile-, leather- and other pollution emitter industry in the North part of Budapest, urgent intervention was required related to the Danube protection. Near the deficiency of economic strength the location of the WWTP caused problems in its really small inhabited environment. Then, the professional authority announced tender, based on which the WWTP was built to the alluvial Palota Island called **North-pest WWTP** (NP WWTP). After the long preparation and with political decision, the implementation was entrusted to a foreign design company with less experience in wastewater treatment and to install equipment of an even less specialized mechanical engineering company. The construction was made by a Hungarian company. The plant was envisaged to 4 x 140 000 $m^3\ d^{-1}$. The biological equipment of the first phase was delivered with several problems in 1986.

After many reconstruction and modernization, with EU financial support a third-stage 1.035 million PE (population equivalent) (200 000 $m^3\ d^{-1}$) WWTP was reconstructed which fulfils the treating criteria. At the last construction phase two 12 000 m^3 anaerobic mesophilic digester were established, in which the mixing is solved by lance gas blowers. It can receive either the activated sludge or (with appropriate pretreatment) communal (mainly from food industry) organic waste (~900 $m^3\ a^{-1}$) (Figure 20).

Figure 20: North-pest WWTP in 2010 (Brochure).

The co-digester equipment can produce significant biogas surplus, which can ensure the WWTP heat-energy demand in 100 % and the electrical energy demand in 80 %. The sludge dewatering is solved by two membrane – and one chamber press. The sludge then is transferred to the open prism composting plant which operated by Budapest Sewage Works. The compost is then used for reclamation purposes (Figure 21).

Figure 21: Open prism composting plant in Csomád (Brochure).

Besides after very long preparation (almost twenty years) in 2002, a consortium leaded by the Sweden SEVECO was entrusted to make a feasibility study, whereby the technical, economic conditions and possibilities of the largest Hungarian plant, the **Budapest Central Wastewater Treatment Plant** (BC WWTP) were examined. The project contained the planned WWTP on the North part of the Csepel Island with size of 29 ha, the main collection channel at the Danube bank of Buda, the related pump stations, the collected wastewater leading under the Danube, the liquidation of the inlets at the bank and more than 350 km collection system. The plant have been built with the third treatment stage, 1.35 million PE (350 000 $m^3\ d^{-1}$) capacity. 3 x 5 800 m^3 anaerobic thermophilic digester reactors were established within the framework of the sludge treatment, and it served the biogas utilization to cover the energy demand of the BC WWTP. It can be interesting that the sludge before the digestion is pasteurized in order to the better efficiency. The dewatered sludge has ~28 % dry matter content and it utilized to the recultivation purposes (Figure 22).

Figure 22: The covered Budapest Central WWTP in 2010 (Brochure).

The BC WWTP with completely covered design in aspect of environmental interest, treating of all the air quantity can increase extremely the electrical energy (~2.0 million m^3 d^{-1}). (The emission limit values: BOD5<25 mg L^{-1}; COD<125 mg L^{-1}; TSS<35 mg L^{-1}; TN<30 mg L^{-1}; TP<2 mg L^{-1}.)

Like all European countries, including Hungary the sludge disposal is persistent problem. However there is not higher poisoning (heavy metal) emission material than the emission limit, but its utilization has difficulties in the agricultural area. Actually the sludge of all the three WWTP is used for recultivation.

In 2015, namely after the last 120 years, it can be said that the Capital city has 100 % covered area in sanitation. The household and industrial wastewater in all sewerage system is connected to the recipient after the third treatment stage. ~1.8 million inhabitants live in the 525 km^2 area of the Capital city. The combined and separated pipes length approach to the 5 700 km. The all capacity of the three plant is 2.7 million PE (630 000 m^3 d^{-1}). The total system and the three WWTP is property of Budapest Municipality.

The operation is made by two organisation. The North-pest and the South-pest WWTPs with associated ~5 300 km collection system is property of the Budapest Sewage Works, the representative consortium partners with 25+1 % share: the operator holding made by Berlin Wasser and Veolia Environment SA. The largest Hungarian Budapest Central WWTP built in the Csepel Island with its related equipment – pursuant to the political decision - is operated by the Budapest Waterworks (Figure 23).

Figure 23: The three WWTP in Budapest with the operation organisations.

The Figure 24 serves the comparison with the Figure 3 presented which shows the city view 200 years ago. This contrast shows gorgeously the temporal change of one of the most beautiful situated European metropolis.

Figure 24: The view of Budapest nowadays (Google).

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