ALTERNATIVES FOR MODERNIZATION OF SLUDGE HANDLING AT THE NOWY TARG WWTP

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SUMMARY

Since year 1996 a final sludge disposal has been a great problem at the wastewater treatment plant in Nowy Targ. The sludge has a high chromium content and poor dewatering properties and after stockpiling at the plant it created severe odour problems. The Division of Water and Wastewater Treatment of the Cracow University of Technology has developed both short -term and long-term strategies to improve the sludge handling process at the plant. As a short -term strategy it was proposed to undertake the following actions: operate the activated sludge process at an extended sludge age, install additional facilities for mechanical sludge dewatering and lime conditioning as well as construction of a sludge (ash) deposit area. As a long-term strategy for sludge handling improvement two possibilities were discussed: Option 1) - construction of primary clarifiers and a sludge anaerobic digester; Option 2) - construction of a sludge incinerator.
The paper discussed the advantages and disadvantages of both options.

KEY WORDS

Sludge handling; anaerobic digestion; sludge incineration; chromium;

INTRODUCTION

The previous papers discussed the changes that occurred in years 1989 - 1992 in the quantity and quality of the municipal wastewaters influent to the Nowy Targ wastewater treatment plant (WWTP). They reflected transformation of the municipal and industrial systems within the city and they influenced mostly the operation of the sludge handling facilities at the Nowy Targ WWTP.

During the plant start - up operation in year 1995 the suspended solids concentration in the raw wastewater was four times higher than the value assumed in the project (100 g/m^3); also the chromium concentration was rather high and the final chromium concentration in the sludge reached 5 000 - 40 000 mg Cr/kg SS. Moreover, due to the lack of primary clarifiers, the excess sludge has remained rich in organic compounds that were not readily destroyed during an aerobic digestion process.

According to the previous assumptions in the design, the dewatered sludge was planned to be finally deposited at the new city landfill, however its construction has not even been started yet, due to the continuous public protests against its location.

After the start-up operation the total average ifluent wastewater flow rate to the plant was:

$$Q = 10\ 000\ m^3/d \quad [\ 48\ \%\ \text{of total capacity}\ ]$$

but the sludge volume generated in the treatment process amounted to 17 - 18 ton wet solids/d; this value comes close to the volume predicted in the project for year 2010. The sludge could not be deposited at the municipal landfill due to its high chromium content and low solids content. Under such circumstances on June 11, 1996, the Regional Inspector of Environmental Protection in Nowy Sącz issued a document in which he refused to provide the Nowy Targ WWTP with the operation permit.

Since the plant has already been in operation for some period of time, the operator had eventually to face the growing problem of sludge handling. Until now, the sludge was piled and stored at the plant site. At first it was stored under the roof, at the nearby operating site; then its volume expanded to the extend that it had to be piled up on the grass land and the area around the plant fence. Since the sludge was not well - stabilized and still contained many residual organics from the hides processing, it created severe odour problems at the plant and in its close vicinity. The magnitude of the problem was so great that it became a serious nuisance for the environment, stirred public protests and generated a great interest in the media.

The investor had to come up with some immediate actions in order to find the successful resolution of the sludge disposal problem and apply for funds to upgrade and modernize sludge handling processes. In June 1996, the plant operator asked the Cracow University of Technology (CUT) to prepare a proposal for upgrading the sludge handling and disposal system at the plant.

The paper describes and discusses the option proposed by the CUT both as short-term and long-term solutions. They are accompanied by the evaluation of their feasibility based on the operational experience and the research experiments conducted at the Nowy Targ WWTP in year 1997-1998.

WASTEWATER CHARACTERISTICS

The authors of the proposed solutions based their estimates on their own wastewater and sludge mass balance. They assumed, that during the plant upgrading the ultimate size of the newly-built process units would be planned for a 10- years period of operation (year 2006), when the estimated wastewater flow rate would be Q_{in} = 13 500 m^3 /d.

It was assumed that the design flow rate Q_{in} = 21 000 m^3/d might occur only in a very long perspective in Nowy Targ; it was also possible that such a flow rate would never be reached in Nowy Targ due to a persisting drop in water consumption caused by the increase of water charges. A sludge mass balance was performed for two options: W_1 - existing technology; W_2 - existing technology and new primary clarifiers.

The total amount of the excess sludge in option W_1 (year 2006) was:

$$SM_{W1} = 4210 \text{ kg/d}, \qquad Q_{W1} = 70.2 \text{ m}^3/\text{d}$$

The volume was calculated for a mechanical thickening process efficiency - 6 % of dry solids.

The total amount of the sludge in option W_2 was:
- primary sludge :

$$SM_{wsst\ 2} = 2830 \text{ kg/d}, \qquad Q_{wsst\ 2} = 56.6 \text{ m}^3/\text{d}$$

- excess sludge:

$$SM_{N2} = 1380 \text{ kg/d}, \qquad Q_{N2} = 23.4 \text{ m}^3/\text{d}$$

In this option two separate sludge thickeners were assumed; a gravity one for primary sludge thickening and a mechanical one for thickening of the excess sludge. The total amount of the sludge produced in year 2006 is:

$$SM_{W2} = 4210 \text{ kg/d}, \qquad Q_{W2} = 79.7 \text{ m}^3/\text{d}$$

In the option W_1 aerobic sludge stabilization was assumed while in the option W_2 the sludge would be stabilized in an anaerobic sludge digester and the methane gas would be used as a heat source.

The efficiency of the sludge stabilization process was expressed as the amount of volatile suspended solids and assumed as 64% VSS after aerobic stabilization and 54% VSS after anaerobic digestion. A difference in both efficiencies is caused by the fact that anaerobic digestion operates at the constant temperature range while aerobic digestion of the sludge in Nowy Targ WWTP proceeds within the temperature ranges 12-15 ^oC (summer) and 5 - 7 ^oC (winter and spring).

The sludge volume for each option, after stabilization and dewatering processes (20% dry solids), would amount to:

$$SM_1 = 3510 \text{ kg/d}, \; Q_{od.1} = 17.5 \text{ m}^3/\text{d} \qquad SM_2 = 2470 \text{ kg/d}, \; Q_{od.2} = 9.1 \text{ m}^3/\text{d}$$

while the design values were:

$$SM_P = 3600 \text{ kg/d}, \qquad Q_P = 18 \text{ m}^3/\text{d}$$

A substantial difference in the design and actual calculations is caused by a poor performance of the thickening and dewatering processes. After gravity thickening and dewatering in the centrifuge the sludge has only 15-18% of dry solids. Therefore the amount of sludge (expressed in tons/d) assumed for year 2010 was already reached in year 1996. In years 1998-2006, according to the estimates provided by the CUT, the city would have to accommodate 36 500 tons of wet sludge (option with the sludge digestion and primary clarifiers) or 70 300 tons of wet sludge, if the present technology remains unchanged.

The detailed flow and sludge mass balances conducted in year 1997 and their further examination, enable to formulate the following conclusions: the amount of the excess sludge decreased from 1.2 kg SS/kg $BZT_{5rem.}$ to 1.0 kg SS/kg $BZT_{5rem.}$, as a result of lower suspended solids concentrations. An average annual concentration in year 1996 dropped from 400 g/m^3 to 270 g/m^3. A high sludge yield assumed in the design was only observed during the few winter and spring months. Therefore, annual predictions of the excess sludge volume at the plant are already overestimated. It should not however influence the size of the future sludge handling units because of a seasonal fluctuations of sludge yield.

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SHORT -TERM SOLUTIONS

The proposal put together by the Division of Water and Wastewater Treatment (CTU) considered the possible sludge handling strategies that could be applied at the Nowy Targ WWTP. They include both short-term and long-term solutions, the latter ones requiring substantial capital investments. The short term solutions were mostly focused on improving sludge dewatering characteristics, reducing its volume and odour problems. Several possible methods were recommended:

- operation of all three SRB reactors to increase the sludge age,
- improve sludge dewatering characteristics by using a mechanical thickener supplementing the centrifuge operation,
- additional conditioning of dewatered sludge with lime to reduce odour problems,
- construction of water-proof containers, partially covered with plastic foil, to store the sludge according to the environmental protection ordinance.

Out of the four proposed solutions only the second one has not been completed yet. The other remedies that had been undertaken as well as the operators own suggestions were presented in a separate paper. It should be pointed out that all short-term solutions were developed in such a way that they could be further incorporated into long-term options.

LONG-TERM SOLUTION

Anaerobic sludge digestion

In the proposal prepared by the CUT a construction of two new circular primary clarifiers was recommended. The new units could be located in the actual sludge storage area and they could be hydraulically linked to the existing treatment system, between the grit chamber and the biological reactors.

In order to fully recognize the existing possibilities, some batch tests of the sludge digestive abilities were conducted at the plant. The tests were run at sludge concentration of 6 kg/m^3 and chromium concentration of 6 g/kg dry solids. The equivalent content of chromium was 0,6 % Cr in dry solids, while the limiting value of chromium content in an anaerobic digester, according to the WEF standards, is - 2.2% Cr in dry solids.

In spite of such a low chromium content, the batch tests showed the inhibition in the production of methane gas (45 dm^3/kg VSS destroyed); the sludge stabilization efficiency, measured as the final organic material content, was 61,4 %. So far there was no opportunity to fully examine the process at a larger scale and for more extended period of time. However, the authors state that anaerobic digestion may be implemented at the plant and the recovered volume of the methane gas can be used to heat up the sludge volume during the winter time; sludge though should be well thickened and the digester must have a sufficient thermal insulation. It may be expected that anaerobic digestion should proceed with much higher reliability with a decreasing chromium concentration in the influent; it also should be less dependent on the varying seasonal temperatures in the Nowy Targ area than aerobic digestion.

Assuming the anaerobic digestion time - 22 days, the required digester volume is:

$$V_{WKF} = 2100 \text{ m}^3$$

The cost includes: gas storage tank, boiler plant and all required technological appliances.

Sludge incineration

Sludge incineration provides the most complete reduction of the sludge volume and assures the evaporation of all water from the sludge. Remaining ashes should be sprinkled with water before further transport and in this case the total mass of wastes for land disposal would amount to 0.68 T/day in year 2006. Sludge incineration is also accompanied by an extensive emission of flue gases to the atmosphere. Nevertheless, at the Polish market there are already companies that guarantee a compliance with the emission standards what makes a sludge incineration option for the Nowy Targ WWTP quite plausible. An incineration option was formulated based on the offer of the Dutch company that developed a similar specification for other Polish wastewater treatment plants. The fluidized bed furnace for the Nowy Targ treatment plant would have 1.0 - 1.2 m of diameter, and together with the other accompaning equipment it would cover the area of 12 x 18 m. The height of the furnace would be H=13 m, including a chimney.

LONG-TERM SOLUTIONS FOR SLUDGE HANDLING

There are three options that may be considered as long-term solutions for the sludge handling problems in the Nowy Targ WWTP, if only a very expensive transport of the sludge to the other regions is excluded. They are:

1. Sludge storage at a new municipal or regional landfill together with the municipal solid wastes; the landfill should have some of its volume reserved for storage of well dewatered and stabilized sludge. The landfill may be located 20 or more kilometers from the plant.
2. Incineration of sludge at the plant and storage of the ashes at an appropriate local land deposit area.
3. Agricultural application of sludge may be discussed only when the wastewater management within 200 small tanneries located in the Nowy Targ area can be better monitored.

The plant upgrading and an expansion of the sludge handling system should proceed in such a way that any of the above scenarios could be employed; in each case very good sludge dewatering is worthwhile.

Option 1 requires a good sludge stabilization and reduction of the organic content; reduction of the sludge volume by heat drying and using the biogas may also be considered.

Sludge incineration may proceed without previous sludge stabilization and requires only heat drying of raw sludge. Before an agricultural use of the sludge, it should be well stabilized and sanitary safe.

LOCAL SLUDGE DEPOSIT

The proposal delivered by the CUT indicates that regardless of which long-term option the plant would prefer, it still will be in the need for a substantial sludge storage area. The area may also provide other technological functions as;

- temporary storage of sludge in case when it cannot be hauled to the municipal landfill due to the transport disturbances (option 1)
- final deposition of ashes or its operational storage in case of incineration process disturbances (option 2).
- storage of poorly stabilized and dewatered sludge, until the sludge handling process will be modernized and the final sludge management strategies are developed.

Assuming that the plant upgrading process would start in 1998 the proposed storage volume was 7600 m^3. Technical aspects of the construction of a storage area were not consulted with the CUT. The storage area was completed in 50% and now it serves as a temporary sludge deposit site.

COSTS ESTIMATION AND SUMMARY

- Estimated project costs are:
  Option 1 - construction of a new anaerobic digester, primary clarifiers and accompanying infrastructure (1996 prices) :

  4 000 000 zł.

  Option 2 - sludge incineration:

  6 000 000 zł.

- It seems that more appropriate solution for the sludge handling problem is the construction of a digester and a combined sludge landfill for both municipal wastes and the sludge from the Nowy Targ

WWTP. The well-digested and dewatered sludge of reduced volume would require lower transportation and storage costs if compared with the costs of sludge after aerobic digestion.

- If the completion of a new landfill takes more than 2 years an incineration option should proceed.
- In a long run both options seem to be more reasonable and less expensive then the option to haul the sludge to the incinerator in Dąbrowa Górnicza.