BEST
Better Efficiency for Industrial Sewage Treatment

Industrial wastewater management model in Adaži wastewater treatment plant, Latvia

Summary of Project BEST output (WP4.1)
Riga Technical University

Introduction

Municipal wastewater treatment systems are important elements of each city's infrastructure. The correct operation of these special technical facilities provides protection of the environment and, consequently, the health of the population (Muralikrishna and Manickam, 2017). The negative side of the processing and manufacturing industry is the generation of specific wastewater, that contains a by-product of the production process. Generated wastewater is unsuitable for discharge into the environment or sanitary sewer system without treatment. The additional load on municipal wastewater treatment process can be created by the volume, the concentration of the substances discharged from industry to the sewerage system (Wenz J.P.E., 2019; Nort East Water, newater.com.au). As a result, the corrosion and clogging of the sewerage system can be accelerated, dangerous odours and gases can be formed, and municipal wastewater treatment process failure can be initiated. The overload with additional volume (short-term high flow discharge) or high concentrations of contaminants (shock load with chemicals) from industry can affect the process of combined wastewater systems of municipal WWTPs (Golovko et al., 2019).
Therefore, the better communication model between representatives of industry and municipalities and methodology for risk management of municipal WWTPs should be developed.
The main objectives of the better communication model and WWTP process management scheme are not only protection of WWTPs personnel, the general public, wastewater treatment process, but also optimisation of the process, facilitation of recycling and recovery of resources and facilitation of regulatory compliance (Nort East Water, newater.com.au).
In turn, the development of the methodology for risk assessment will implement best practices for wastewater management, and as result, will reduce the negative effect on the environment due to reduced wastewater treatment process failure events (Loj-Pilch and Zakrzewska, 2020). Considering the potential risks at an early stage allows for choosing correct actions and reduce costs for the industry due to high contaminant level in the discharged wastewater.

The aim of this activity was (1) to determine the main factors (technological and chemical) that can affect the operation of municipal wastewater treatment plant in Adaži and (2) to evaluate the list of the recommendations for both sites of representatives (industry and municipality) to improve industrial wastewater management scheme.
The better communication model and WWTP process management scheme thought the risk assessment procedure was evaluated in the Adaži district of Latvia.

Description of study

A study was performed in the Adaži district of Latvia where significantly increase the number of food production factories and, therefore, a load of the amount of wastewater and different contaminants.
The main participants were municipal WWTP, fish, chips, vegetables processing factories, and public catering place. Results obtained from the pilot study at the dairy production "Latvijas Piens" Ltd were included in the WWTP process management scheme.

In general, the work was divided following steps:

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1. Regular communication with representatives of Adaži water Ltd. and collection of information about the WWTP efficiency and failures;
2. Individual communication with r representatives of factories and collection of information about the used pre-treatment technologies, its efficiency, and failures;
3. Development of the wastewater monitoring programme for each study participant aimed at technological process problem identification;
4. Sampling, sample analysis, and data processing;
5. Evaluation of recommendations for each study participant for better communication model and WWTP process management.

Timing: from the 1st Mart 2019 until 30th April 2020.

WWTP monitoring

The WWTP monitoring programme for at least 5 days was developed for each participant under the study. The lists of chemical composition were based on the survey of the technological process and knowledge and experience of RTU experts. The processing intensity (work hours, minimal and maximal wastewater load), properties of technological process (possible chemical composition), and nuances of technological services (chemicals used for cleaning, frequency of maintenance) were taken into account. An individual timetable for sampling was developed.
Wastewater samples were collected from a pilot and full-scale systems in plastic carboys (2 L) stored in a refrigerator (2ºC to 5ºC) after transportation and analysed within 24 h for their chemical characteristics. All analyses were conducted according to the standard methods (Table 1) in an accredited laboratory.

Table 1. Water quality analytical methods

Parameter	Reference
Chemical Oxygen Demand	ISO 15705:2002
Biological Oxygen Demand	LVS EN 1899–1:1998
pH	LVS EN ISO 10523:2012
Conductivity	LVS EN 27888:1993
Elements	LVS EN ISO 17294–2:2016
Chloride	LVS EN ISO 10304-1:2009
Suspended solids	LVS EN 872:2005
Total phosphorus	LVS EN ISO 15681-1:2005
Orthophosphate	LVS EN ISO 15681-1:2005
Total nitrogen	LVS EN ISO 11905-1:1998
Ammonia nitrogen	LVS ISO 5664:2004
Nitrate nitrogen	LVS EN ISO 13395:1996
Nitrite nitrogen	LVS EN ISO 13395:1996
Fat	US EPA Meth. 1664B:2010

Electrical conductivity (EC) and pH level were determined using Multi 340i SET B (WTW, Germany) at the sampling site.

Results

To determine the main factors (technological and chemical) that can affect the operation of the municipal wastewater treatment plant in Adaži the monitoring programme and timetable were developed. An example of the form used during the study is shown in Table 2.

Table 3 is the example of data processing of chemical analysis. Results showed a list of chemical parameters determined in all wastewater samples and its minimal and maximal values. Maximal value of chemical parameters are obtained from untreated industrial wastewater sample analisys and equal for maximal contaminant level in industrial wastewater that can be discharged into the sewage system.

The information (Table 2 and 3) and processing of data allowed us to understand the composition of wastewater after processing the factory, operation of the local pre-treatment system, to fix failures during the monitoring system, and to develop lists of possible inhibitors that can affect municipal WWTP.

Table 2. Timetable for sampling and technological process evaluation.

Date	Sampling place	Time[1]	Processing work hours, h	Salt[2], kg/d	WW amount, l/d	Workshop cleaning reagents[3], l/d		Specific notes	Measurements at the sampling place		
						alkaline	chlorine		pH	T, ^{0}C	EVS, mS/cm
Day 3	IN	6:00	8	300	111	57	40	Fat catcher clogging	7,32	12,3	12,8
	OUT								7,37	14,7	3,3
	IN	14:00							7,67	12,6	7,5
	OUT								7,34	12,3	12,8
Day 5	IN	6:00	12	1350	93	57	40	-	7,2	12,8	7,4
	OUT								8,3	12,9	28,1
	IN	14:00							10,1	8,9	3,7
	OUT								9,8	8,6	6,2

[1]At minimal load and maximal load; [2] Specific reagents used in processing; [3]Specific reagents used for factory workshop cleaning

Table 3. Results of chemical analysis of industrial wastewater.

Parameter	Minimal value	Maximal value
pH	5,7	9,8
EVS, mS/cm	1,394	1,962
COD, mg/l	252	18930
BOD_5, mg/l	126	7809
Suspended solids, mg/l	100	9938
Tot P, mg/l	1	86,9
P-PO_4, mg/l	0,082	5,7
Tot N, mg/l	12,5	302
N-NH_4, mg/l	2,52	55,2
N-NO_3, mg/l	0,194	6,2
N-NO_2, mg/l	0,04	10,4
Fats, mg/l	34	625
Chloride, mg/l	101	258

To evaluate the list of the recommendations for both sites of representatives (industry and municipality) to improve industrial wastewater management scheme technological process risk assessment was performed (Table 4) (Loj-Pilch and Zakrzewska, 2020; Pollard, 2016).

Table 4. Example of clarification of data that can be used for risk assessment description.

Parameter or device	Event	Type of risk[1]	Identification of risk			Risk assessment		
			Factor[2]	Effect	Action	Number of losses (L)[3]	Frequency of appearance[4] 1/year	Frequency of appearance[4] F
Fat catcher	Clogging	OP	O	Overflow /floods	Manual cleaning of the system	1	9	2
Tot N	Concentration to high	Q, Fi	I	Overload with N	Report to MWWTP operator	2	>9	3

[1]Types of risk: Q - qualitative, OP- operational; EC - ecological, Fi – financial; [2]Factor: O – ordinary, E – external, I – internal; [3]Number of Losses (L) meets to the type of risks, for example, Q =1, Q+OP=2, Q+OP+Fi=3, Q+OP+Fi+EC=4; Frequency of appearance of threats identified in study and evaluated according to Loj-Pilch and Zakrzewska, 2020.

During the study the occurring risk factors and frequency of their occurrence were determined, type of risks, risk identification, and assessment were evaluated. The key participants were municipal WWTP and 5 food processing factories: fish processing (Factory A, 3,1% % v/v (industrial wastewater volume per total wastewater volume at WWTP)), chips production (Factory B, 11% v/v), public catering place (Factory C, 0,4% v/v) vegetables processing (Factory D, 0,5% v/v), and dairy production (Factory E, 4% v/v).
The groups of fixed risks were technological, financial, and qualitative (see summary in Table No. 4).

Table 5. Summary of the study.

Nr.	Factory	Days of monitoring	Failure description	Numbers of occurrences	Effect on MWWTP[1]
1	A	5	Tot N too high	4	low
2			Tot P too high	4	low
3			High pH level	2	low
4			Salt concentration too high	1	medium
5			Fat catcher clogging	1	low
6	B	5	Oil emission into the sewage	1	significant
7			Salt concentration too high	4	low
8			Fat catcher clogging	1	low
9			Failure of the biological treatment process	2	low
10	C	4	Fat catcher clogging	3	medium
11			COD and BOD_5 too high	2	low
12	D	4	Settler clogging	2	low
13			COD and BOD_5 too high	1	low
14	E	12	Fat emission into the sewage	12	significant
15			Salt concentration too high	2	significant
16			Tot N too high	12	medium
17			Tot P too high	12	medium
18			COD and BOD_5 too high	12	significant

[1]Effect on municipal WWTP is calculated as the ratio between produced WW amount and total WW amount received by MWWTP and comparison of the obtained value with legislation or literature data: low - concentration complies with legalisation rules or literature data; medium - concentration after dilution in the sewage system complies with legalisation rules or literature data; significant – contamination affect process of MWWTP.

In total, 18 failures or risks in total were identified and evaluated:

1. The main qualitative risk for municipal WWTP relates to the high concentration of chemical contaminants in industrial wastewater. Almost all failures were on acceptable level for factories A-D, and, unfortunately, significantly exceeds the permissible limits for factory E. The possibility of occurrence of this risk is medium and significant due to the lack of appropriate pre-treatment technologies at the factory E.
2. The technological risks relate to the response of staff and relevant services. Proper functioning of the pre-treatment system has a significant effect on the sewage system. The identified failures may lead to disruption of municipal WWTP. The fixed technological failures as a fat catcher, clogging of the settler, or disruption of biological pre-treatment was evaluated as low or medium taking into account response from the staff and concentration of contaminants in wastewater samples after dilution in the sewage system. Risks may arise as these events require a regular response from the staff. To remove these risks the professional operator and regular technological service are necessary.
3. The financial risk is evaluated as significant due to its effect on wastewater quality, sewage system operation, and environment (Factory E). Due to a lack of funding for construction, the treatment system does not exist. As well as the lack of the local pre-treatment is directly linked to the additional financial losses due to higher rates of overloaded discharges. One failure was related to an operational mistake at the factory B and delay in the response from the staff. To reduce these risks the funding for appropriate technology and a regular response from the staff are necessary.

All of the study participants have an interest in future cooperation. To reduce potential risks workshops for representatives from industries and municipalities are planned*. Dissemination activities are necessary to increase knowledge about new technologies and processes in the wastewater sector, as a result, increase interest opportunity to add appropriate technology into practice. The potential collaboration between municipalities will be discussed to seek the most appropriate solution for both partners at the local meetings. Thus, all evaluated risks can be reduced to a minimum.

Conclusions

The municipal sewage treatment plant under the study functions property. In total, 18 failures or risks were identified and evaluated. Only 4 detected risks are evaluated as significant due to the lack of pre-treatment technology and an operational mistake at the factory, 4 technological risks were evaluated as medium and 10 – qualitative risks as low. The recommendations for both sides of representatives (industry and municipality) to improve industrial wastewater management scheme are the following:

1. regular communication between operators at factories and municipal WWTP;
2. fair transfer of information about technological processing or failures;
3. attracting professional operators for work;
4. regular training for employees.

Regular communication allows increasing knowledge about the real situation at the existing wastewater discharge point (at factories) and at the WWTP.

References

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Notes

[*] *Some activities of the project were canceled in accordance with the decision of the Government of Latvia or at Riga Technical University due to the COVID-19 concerns. All activities are still planned.*