

ECOLOGICAL EVALUATION AND PERFORMANCE EFFICACY OF THE WASTEWATER TREATMENT PLANT AT A POULTRY MEAT PROCESSING ENTERPRISE

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SUMMARY

The study aimed to perform an ecological evaluation of wastewater treatment plant (WTP) efficacy at a poultry meat processing enterprise. The results from the monitoring of wastewater treatment plant performance for 2008-2012 were analysed and compared to the current legislative framework, i.e. Ordinance No 6/9.11.2000 and the implemented internal monitoring programme (IMP) for control of the work of the WTP. WTP control is carried out as four analyses on an annual basis, as the pollution of wastewater is under 4000 population equivalents and wastewaters are not discharged in sensitive areas (art. 16, para 8, Ordinance 6/9.11.2000). The meat processing enterprise controls strictly the performance of the WTP through the IMP. The requirements of the programme with regard to the parameters chemical oxygen demand (COD), biological oxygen demand (BOD₅), and fat in water are three times lower. For the 5-year period of the survey, only a single episode of wastewater discharge with insoluble matter over the limit of 50 mg/dm³ was recorder (23.12.2008). An important parameter for the efficacy of WTP performance was the amount of fat in treated waters. Three discharges of treated waters which exceeded the limit of 10 mg/dm³ set by the legislation were recorded. The first episode showed a value of 78.4 mg/dm³, i.e. almost 8 times higher than the limits. During the next two pollutions of the river Azmaka used as water source, recorded values were 16.3 and 18.4 mg/dm³, i.e. almost twice higher than norms. The enterprise exerts a strict control with respect to this parameter by setting three times lower limits in the IMP than those in the legislation. This was particularly evident after the analysis of results, where apart the mentioned pollution episodes over the 5-year period, only two additional cases of parameters exceeding the IMP limits were established. The specific activity of the enterprise reveals that the amount of wastewater fat is of key importance for the quality of WTP performance and requires control of this parameter.

Key words: wastewater treatment plant, pollution, wastewater, insoluble matter, fat

Abbreviations: wastewater treatment plant – WTP, chemical oxygen demand (COD), biological oxygen demand - BOD₅, insoluble matter – IM, internal monitoring programme – IMP, internal laboratory methods – ILM, Bulgarian state standard – BSS, East Aegean region – EAR.

Introduction

Water is a natural resource essential for human life. It is one of primary environmental components, whose quantity and quality determines the natural equilibrium and life in general. The development of the industry and improved sanitation of the population result in higher amount of wastewaters. Before being discharged in the water pools, they have to be purified according to the requirements of the respective design category. Polluted wastewaters are a permanent source of infectious, parasitic and toxicological diseases for both animals and humans.

The main instruments for integrated water management is the water plan, developed on both basin and national plans. Basin plans for integrated water management according the the Water Act are developed over 6-year periods. They serve for analysis and evaluation of the hydrographic and hydrological characteristics and for a general assessment of water resources. The anthropogenic load and its impact on waters is also analysed (Water Act, SG 67/1999). According to the Water Act, the National Water Plan is developed for a 12-year period. It deals with the distribution of water among river basins, and sets of investment policy priorities in the sector, monitoring principles and execution control.

Water pollution not only makes it unfit for a number of purposes, but also incurs damages to the entire environment. Polluted waters are responsible for the extinction of representatives of plant and animal species, reduce the populations of waterfowl and other animals, whose habitats are located close to contaminated water sources (Ignatova, 1992).

Depending on the nature of pollutants, waters are contaminated with (Ignatova, 1992; Iliev, 2003):

- a) mineral and organic non-toxic substances
- b) mineral and organic toxic substances
- c) inert contaminants

Wastewaters from agriculture and livestock husbandry pose a serious risk for water pollution. Wastewaters from animal farming operations contain organic and inorganic suspended matter, ammonia, nitrites, nitrates and microorganisms (Kostadinova, 2003; Petkov, 2006; Stefanova, 2012). Animal facility wastes are solid or liquid manure, which favours the development of a number of infectious diseases in men. The sanitary assessment of solid and liquid manure shows that they contain more than 30 non-pathogenic microbial species, mostly aerobes. The manure of sick animals could be a source of more than 100 zoonotic diseases.

The purpose of the present study was to make an ecological evaluation of the performance of a wastewater treatment plant at a poultry meat processing enterprise.

Material and methods

The studied facility was the water treatment plant to a poultry meat processing enterprise. Its capacity for treatment of industrial wastewaters was equal to 5-day biological oxygen demand (BOD₅) of 26.4 kg or 500 population equivalents. One population equivalent (p.e.) is the amount of 24-hour organic biodegradable load containing BOD₅ = 60 g oxygen. The enterprise is built in the land of Kolarovo, Radnevo municipality, Stara Zagora region (Fig. 1).

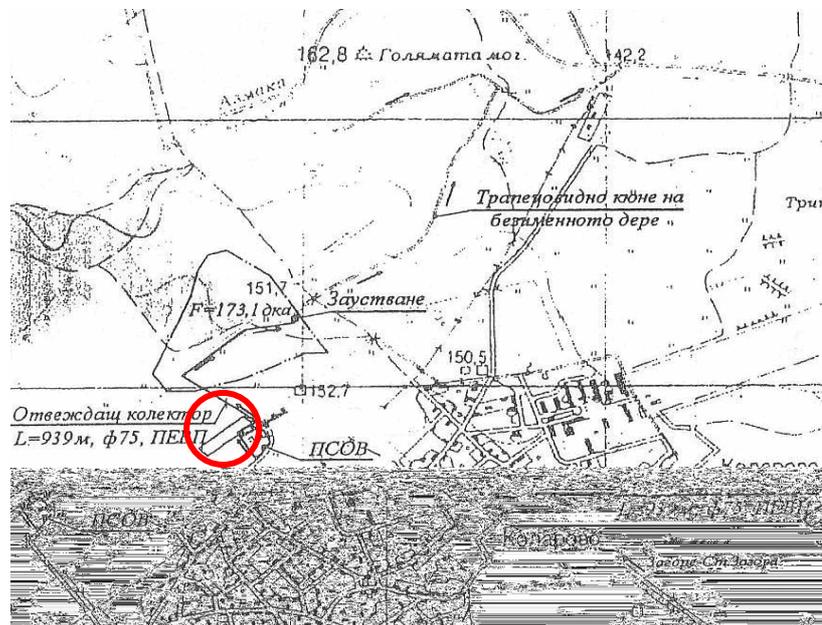


Fig. 1. Location of the water treatment plant (red circle) in the land of Kolarovo village, Radnevo municipality

The wastewaters from the poultry meat processing enterprise are discharged in a superficial water basin “Azmak river nulla”, for which the enterprise has a permit for discharge of wastewater in superficial receiving waters (33740009/19.10.2007) issued by the Basin Directorate for water management - East Aegean Region, Plovdiv. The permit for discharge of wastewaters in receiving

waters is regulated by the Water Act as well as by Ordinance 10 from 3.07.2001. The ordinance settles the procedure and way of issuing permits for discharge of wastewaters from point sources of pollution in superficial receiving waters. The ordinance's aim is to protect waters receiving wastewaters clean, providing the respective design category according to water usage, water quality and to create favourable conditions for normal development of aquatic ecosystems.

Treated water samples (2 L) from the enterprise's WTP were collected on a periodical basis (four times a year) from 2008 to 2012. The following parameters of collected water samples were analysed in an accredited lab:

1. Active reaction (pH)
2. Insoluble matter (IM)
3. Chemical oxygen demand (COD)
4. Five-day biological oxygen demand (BOD₅)
5. Extractable fat

The determination of aforementioned parameters was conducted as followed:

- pH – as per BSS 17.1.4.27:1980;
- IM – as per BSS 17.1.4.04:1980;
- COD – as per ISO 6060:1989;
- BOD₅ – as per BSS EN 1899-1:2004 and BSS EN 1899-2:2004;
- extractable fat – as per internal laboratory methods (ILM).

The efficacy of WTP performance was monitored through analysis and comparison of data from analysis protocols as per the internal monitoring programme of the enterprise and Ordinance 6/9.11.2000. The included parameters were: pH, insoluble matter (IM), COD, BOD₅, and fat. The WTP water sampling procedure and frequency of the enterprise was compliant to art. 21 of Ordinance 6/ 9.11.2000. Emission norms for total nitrogen and total phosphorus were excluded from the WTP monitoring programme, as the pollution load of wastewaters was under 4000 p.e. and they were not discharged in sensitive zones (art. 16, para 8, Ordinance 6/ 9.11.2000).

Results and discussion

Wastewater characteristics

The wastewaters from the poultry meat enterprise were characterised with high concentration of organic pollutants as insoluble matter (organic tissue residues) and in dissolved form. The amount of dissolved pollutants was determined by the parameters COD and BOD₅. A specific feature of wastewaters was the high extractable pollution due to animal fat.

volume and chemical parameters of wastewater for treatment in the WTP

According to the internal monitoring programme of the enterprise, the flow rates of the different categories wastewaters were as followed (Table 1).

Table 1. Water flow rate for treatment in the WTP according to the category

<u>Technological wastewater</u>	
Daily flow rate	40 m ³ /24 h
Average flow rate per shift	2.5 m ³ /h
Maximum hourly flow rate	8.8 m ³ /h
<u>Domestic wastewater</u>	
Daily flow rate	8 m ³ /24 h
<u>Total volume of wastewaters</u>	48 m³/24 h

Table 2 depicts the chemical parameters of treated wastewaters with maximum pollution limits for efficient performance of the WTP and the requirements to treated waters discharged in category II receiving waters according to the IMP and Ordinance 6/9.11.2000.

Table 2. Chemical parameters prior to and after treatment of polluted wastewaters discharges into category II receiving waters.

Parameters	Prior to treatment mg/dm ³ (IMP)	After treatment mg/dm ³ (IMP)	Ordinance 6/9.11.2000 mg/dm ³
BOD ₅	2500	15	50
COD	5000	70	250

The data from Table 2 suggest that the IMP of the enterprise poses a stricter control on WTP performance, because its allowances are three times higher than those ruled by Ordinance 6/9.11.2000 with respect to wastewater discharged into water bodies. This certifies the enhanced interest of the enterprise in environmental protection. It is further evidenced by the fact that IMP provides BOD₅ reduction by more than 160 times, and COD reduction by more than 70 times during the treatment.

In the WTP, the wastewaters are subject to three-stage treatment as followed:

- mechanical separation of large pollutants through a self-cleaning grid
- physicochemical treatment – by addition of polyfloculant and coagulant (ferrous sulfate) followed by flotation;
- biological treatment.

The data about pH and insoluble matter (IM) in treated waters for 2008-2012 are presented in Table 3. The analysis of data showed that throughout the 5-year survey period, there were no deviations from the water pH allowances. According to Appendix 5 to art. 16, para 1, chapter 11.1. of Ordinance 6/9.11.2000, allowed water pH range could vary within 6 and 9. The minimum-maximum pH values ranged between pH = 7.07 on 05.03.2012 and pH = 8.51 on 17.09.2012. The narrow variation range of wastewater pH confirmed the high performance efficacy of the WTP and the low anthropogenic load on the used receiving water source with respect to this parameter.

As insoluble matter in water was concerned, the IMP of the enterprise complied to the requirements set by Ordinance 6/9.11.2000. For the 5-year period of the WTP performance survey, only one case of deviation over the allowed limits was registered on 23.12.2008.

It should be noted that this deviation occurred by the end of the first year of the WTP exploitation. It is well known that at that time of the year, the production of meat products is markedly increased due to the increased consumption.

The allowances of the IMP with respect to the chemical oxygen demand (COD), biological oxygen demand (BOD₅) and fat in treated water were three times lower than those ruled out in Ordinance 6/9.11.2000. The data about these poultry meat enterprise WTP parameters are summarised in Table 4.

The results indicated that measured wastewater COD values during the 5-year monitoring period did not exceed values set by Ordinance 6/9.11.2000. With respect to the IMP values, measured COD were within the allowed range except for values measured on 07.07.2008 and 13.10.2008. For the first case, the result was close to limits – 68. The results on 07.07.2008 and 13.10.2008 were the highest recorded COD values for the 5-year survey period. Most probably, the cause for increased COD was the putting into operation of the water treatment plant and the existing WTP management practices. The strict control of the WTP performance was also evident from BOD₅ data, shown in Table 4.

The highest measured BOD₅ value (41 mg/dm³) similar to COD value, was on 13.10.2008. Together with the results on 28.12.2009, these were the only cases of BOD exceeding the IMP

limits of the enterprise, but nevertheless, the values were lower than those set in Ordinance 6/9.11.2000. It could be affirmed that with regard to this parameter, the WTP performance was efficient and the receiving waters were not polluted.

The data recorded on 07.07.2008; 13.10.2008 and 23.12.2008 are alarming, as they exceeded the limits of the Ordinance about wastewater extractable fat (Table 4). Also, the limits set by the IMP were exceeded on 30.03.2009 and 28.02.2011. The high content of fat in waters during the first and second year of WTP operation could be possibly due to flaws in finding an optimal technological solution for removing the large amounts of animal fat. The specifics of the enterprise's operations – production of large amount of organic matter with high fat content – requires adequate management and technological approaches aimed at guaranteeing a high-quality treatment of wastewaters.

Conclusion

The requirements for performance of the WTP at a meat processing enterprise included in his internal monitoring programme underline clearly the critical points by imposing allowances lower than those provided by Ordinance 6/9.11.2000. The data from WTP performance demonstrated that the most critical parameter was the fat content, which exceeded in several occasions the limits not only of the IMP but of Ordinance 6/9.11.2000 as well. This fact indicated clearly that the environmental risk, particularly the risk for the Azmaka river used as receiving water source, was posed by the content of fat in treated wastewaters. The specific characteristics of the enterprise's operations necessitates an optimal solution of this problem.

Another important hazard for the receiving water source is the presence of insoluble matter in treated wastewaters. The IMP regulations with respect to this parameter are the same with those of Ordinance 6/9.11.2000. During a significant part of the 5-year monitoring period, insoluble matter values were close to the limits, which compels a more meticulous control on this parameter to avoid pollution of the water source used for discharge of wastewaters.

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Table 3. Data from analysis of pH and insoluble matter (IM) in treated water for 2008-2012 and requirements of the IMP and Ordinance 6/9.11.2000

Analysis date	pH			Insoluble matter		
	Result	Requirements of the IMP	Requirements of Ordinance 6/9.11.2000	Result mg/dm ³	Requirements of the IMP mg/dm ³	Requirements of Ordinance 6/9.11.2000 mg/dm ³
30.01.2008	7.55	6.0-9.0	6.0-9.0	36.5	50	50
07.07.2008	7.91	6.0-9.0	6.0-9.0	47.8	50	50
13.10.2008	7.50	6.0-9.0	6.0-9.0	16.6	50	50
23.12.2008	7.47	6.0-9.0	6.0-9.0	55.7	50	50
30.03.2009	7.74	6.0-9.0	6.0-9.0	12.2	50	50
29.06.2009	7.71	6.0-9.0	6.0-9.0	40.6	50	50
19.10.2009	7.37	6.0-9.0	6.0-9.0	43.9	50	50
28.12.2009	8.01	6.0-9.0	6.0-9.0	33.3	50	50
17.03.2010	7.44	6.0-9.0	6.0-9.0	32.1	50	50
31.05.2010	7.78	6.0-9.0	6.0-9.0	45.9	50	50
08.09.2010	7.93	6.0-9.0	6.0-9.0	49.3	50	50
20.12.2010	7.87	6.0-9.0	6.0-9.0	27.3	50	50
28.02.2011	7.89	6.0-9.0	6.0-9.0	20.5	50	50
30.05.2011	7.47	6.0-9.0	6.0-9.0	35.2	50	50
07.09.2011	7.47	6.0-9.0	6.0-9.0	21.0	50	50
12.12.2011	7.87	6.0-9.0	6.0-9.0	26.9	50	50
05.03.2012	7.07	6.0-9.0	6.0-9.0	45.8	50	50
14.05.2012	8.00	6.0-9.0	6.0-9.0	46.1	50	50
17.09.2012	8.51	6.0-9.0	6.0-9.0	19.6	50	50
26.11.2012	7.46	6.0-9.0	6.0-9.0	29.6	50	50

Table 4. Data from analysis of chemical oxygen demand (COD), biological oxygen demand (BOD₅) and fat in treated water for 2008-2012 and requirements of the IMP and Ordinance 6/9.11.2000

Analysis date	COD			BOD ₅			Fat		
	Result mg/dm ³	Requirements of the IMP mg/dm ³	Requirements of Ordinance 6/9.11.2000 mg/dm ³	Result mg/dm ³	Requirements of the IMP mg/dm ³	Requirements of Ordinance 6/9.11.2000 mg/dm ³	Result mg/dm ³	Requirements of the IMP mg/dm ³	Requirements of Ordinance 6/9.11.2000 mg/dm ³
30.01.2008	68	70	250	13	15	50	0.3	3.0	10
07.07.2008	80	70	250	7	15	50	78.4	3.0	10
13.10.2008	89	70	250	41	15	50	16.3	3.0	10
23.12.2008	10	70	250	2	15	50	18.4	3.0	10
30.03.2009	18	70	250	2	15	50	4.20	3.0	10
29.06.2009	21	70	250	10	15	50	0.30	3.0	10
19.10.2009	30	70	250	7	15	50	0.20	3.0	10
28.12.2009	9	70	250	31	15	50	0.56	3.0	10
17.03.2010	30	70	250	2	15	50	0.92	3.0	10
31.05.2010	57	70	250	10	15	50	2.58	3.0	10
08.09.2010	30	70	250	7	15	50	1.44	3.0	10
20.12.2010	42	70	250	3	15	50	1.08	3.0	10
28.02.2011	18	70	250	3	15	50	3.72	3.0	10
30.05.2011	18	70	250	4	15	50	0.56	3.0	10
07.09.2011	19	70	250	10	15	50	0.96	3.0	10
12.12.2011	35	70	250	2	15	50	2.71	3.0	10
05.03.2012	13	70	250	6	15	50	2.79	3.0	10
14.05.2012	23	70	250	8	15	50	2.35	3.0	10
17.09.2012	44	70	250	12	15	50	0.59	3.0	10
26.11.2012	27	70	250	10	15	50	1.80	3.0	10