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WASTE WATER FROM INDUSTRY OF MILK AND DAIRY PRODUCTS IN KRAGUJEVAC

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Abstract Industry of milk and dairy products is among the smaller producers of waste water in the industry of food products. However, despite this fact, this industry should not be neglected when it comes to its relationship to the environment. Although there are clear regulations and laws obliging them, dairies in Serbia mostly are not complying with applicable legal standards. The waste water is discharged from the plant, but it happens that due to its incapacity, processing of the limit values of the emissions of pollutants cannot be reached. All of this result with negative impact on the environment. The aim of this paper is to present obstacles that prevent better implementation of waste water treatment, specific consumption of water in dairies, as well as the place of wastewater formation. In the paper are presented the results of specific water consumption as well as the results of waste water in dairies in the city of Kragujevac, and finally there are presented the best rates for waste water treatment.

Keywords: milk and dairy products industry; waste water; waste water treatment; COD; BOD_5; best available techniques (BAT).

1. INTRODUCTION

Waste water from industry of milk and dairy products constitute an aqueous solution of milk and dairy products in which there are dissolved other substances (detergents, disinfectants, lubricants, chemical substances added during the water treatment, washing of a tank...). Waste water from industry of milk and dairy products include high levels of protein, carbohydrate and fat, high concentrations of suspended solids, high values of COD and BOD_5, large variations in pH value... [1]. Proper waste water management provides a lot of benefits, beside protecting environment by reducing the amount of generated waste. The benefits include additional savings from cost reduction and resource recovery. There is also the possibility of additional earnings. In order to achieve all of this, waste water must be treated according to the laws and regulatives, using the equipment correctly and planing the changes in order to increase the efficiency of the entire enterprise [1-4].

In the literature can be found a number of papers with the results of various methods used for the reduction of waste materials in waste water. For example, in [5] is shown a study in which anaerobic fixed-bed reactor with polypropylene pall rings is used for digestion of dairy industry effluent. The results show that this method can reduce the COD by 87%, with the maximum production of bio-gas in an amount of 9.8 l/day.

In [6] for treating of waste water from the dairy industry Fixed Film and Fixed Bed Anaerobic Reactors are used. Maximum COD reduction is about 80.88%, for a varying influent COD from 1500 to 4700 mg/l for the OLR of 0.004 kg COD/m^2/day and HLR of 0.003 m^3/m^2/day. Maximum production of bio-gas in this case is 0.265 m^3/kg of removed COD.

The Anaerobic Packed Bed Bioreactor (UAPB) with an internal diameter of 20 cm and a height of 45 cm, which uses shell as a packing material for dairy waste water treatment, may be very good solution [7]. With this method methane (biogas) with very good performance can be produced. COD in this case is reduced from 71526 mg/l to 42200 mg/l, during the 56 days of the experiment.

In [8] has been studied a large number of materials which can contribute to the reduction of BOD_5, COD and suspended volatile matter in the dairy waste water. Anaerobic Fixed Film Bioreactor was used. The materials in this study included, among other things, bamboo rings, PVC rings, fire bricks and gravels. At the end it was found that the percentage of the COD removal is 96%, BOD_5 in the amount of 93%, and the suspended material by 90% can be achieved with the use of 21 kg COD/m^3/day of gravel.

2. WASTE WATER FROM INDUSTRY OF MILK AND DAIRY PRODUCTS

2.1. Obstacles for the treatment of waste water

As obstacles for the treatment of waste waters in the food industry, and therefore in the milk and dairy products industry, are cited [1, 9, 10]:

- misconceptions that are become basic among the population in Serbia ("our country is rich with water", "we have a lot of quality water for supply", etc.);
- economic benefits of waste separation is often very small;
- there are no people/institutions that want to buy new products (obtained by treatment of waste water);
- lack of clear regulations and initiatives for re-separation and recycling of the product and thus to contribute to the preservation of the environment;
- non-compliance and non-enforcement of existing legal norms relating to environmental protection;
- low costs and penalties for the disposal of waste for companies who produce it;
- low costs of water use and waste water discharge.

2.2. Specific water consumption in the industry of milk and milk products

The amount of water that are necessary to dairies for the process of production, mainly depend on: production program (prescription and type of product), equipment maintenance, staff qualifications and age of equipment.

Table 1 shows the specific consumption of water (based on the amount of water consumption of the treated milk) in some dairies in Europe according to the production program [11].

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Table 1. Water consumption in European dairies.

Country	Water consumption [liter of fresh water/liter of treated milk]		
	Milk and dairy drinks	Cheese	Milk powder and cheese
Sweden	0.98-2.80	2.00-2.50	1.70-4.00
Denmark	0.60-0.97	1.20-1.70	0.69-1.90
Finland	1.20-2.90	2.00-3.10	1.40-4.60
Norway	4.10	2.50-3.80	4.60-6.30
Poland	0.50-0.75	2.22	1.80-5.30

In this study two dairies in Kragujevac were analyzed, both are engaged in the production of pasteurized milk and other dairy products. Dairy "A" has an average of 3.39 m^3 of water per ton of processed milk (Figure 1), while dairy "B" has 3.18 m^3 of water per ton of treated milk (Figure 2). If we compare the dairies that were part of this study and the European dairies (Table 1), we can conclude that their specific consumption is similar to the dairies in Norway.

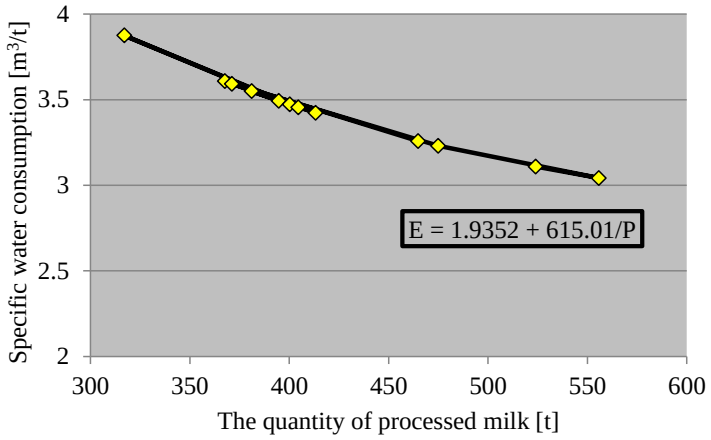

Figure 1. Specific water consumption in dairy "A".

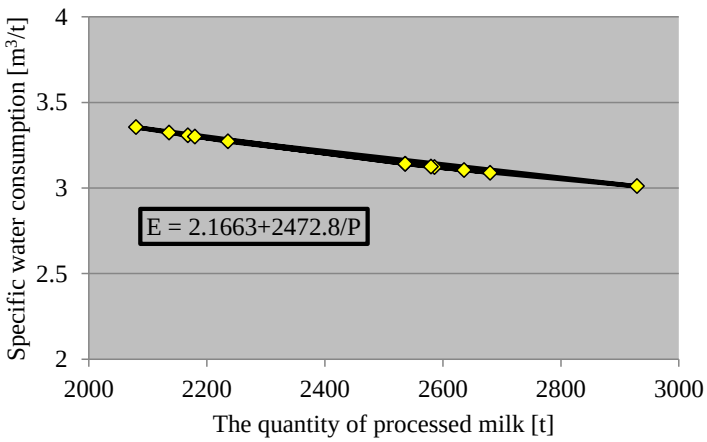

Figure 2. Specific water consumption in dairy "B".

2.3. Categorization of waste water in dairies

Wastewater in the industry of milk and dairy products can be divided into three main categories [12-14]:

- process water;
- industrial waste water;
- sanitary waste water.

Process water includes water used in the process of cooling and heating. It can be in all three aggregate state. These waste waters do not include the pollutants and can be re-used after a minimal processing or drain into the recipient or a public sewerage system [12-14].

Industrial waste water mainly comes from cleaning equipment which is in contact with milk or dairy products. These waters are also obtained due to: spilled milk and dairy products, discharging of cheese, spilling the brine, using CIP cleaning, due to the cancellation of various devices, operational errors, accidental discharges and damages to equipment and process lines. This water must be treated to its limited values before discharge, which in Serbia is not the case [12-14].

Sanitary waste water are normally taken to the recipient, or public sewage or waste water treatment plant. It can be treated before discharge. You can mix this water with industrial water and then disgharge. But this water (sanitary and industrial) should be treated first before discharge [12-14].

2.4. Research results

When we talk about the quality of wastewater testing, most of dairies are not implementing the testing at all because it is not on their list of priority measures. Even those that implement it, do not do it regularly (once or twice a year, rarely quarterly), which is not a good practice.

The waste water sample needs to be taken every 2 hours [9, 15]. The production in the milk industry is taking place in three shifts. If you take into account that the production of the most common type of batch (production is not uniform throughout the day), it is concluded that the data taken once or twice (or even four times) per year do not play any role in the analysis of the state of waste water in the company. Quantity of waste water formed during production of the cheese cannot be the same as in the production of another product. Also, data can be taken at the time when the concentration of pollution was the highest or lowest.

In the following tables (Table 2, Table 3) are shown the results of testing the waste water from milk industry in Kragujevac, Serbia (Dairy "A" and dairy "B"). Both dairies discharged waste water into the public sewage system, the data refer to year 2016 and were taken on a quarterly basis.

Table 2. The results of waste water in dairy "A" in Kragujevac in 2016.

Parametar	Unit	Allowed value	Quantity / Description			
			I quarter	II quarter	III quarter	IV quarter
Temperature	[°C]	<35.0	12.0	12.0	21.0	24.0
Appearance	[-]	-	Grey	Milky white	Milky white	Milky white
pH	[-]	6.0-9.0	7.31	**11.25**	7.81	**11.5**
Ammonia	[mg/l]	15.0	0.15	1.2	0.1	0.3
Ortho-phosphates	[mg/l]	1.0	0.216	**3.258**	0.104	0.622
COD	[mgO_2/l]	450.0	203.0	**469.0**	335.0	**718.0**
BOD_5	[mgO_2/l]	300.0	173.0	**398.0**	284.0	**610.0**
Suspended solids	[mg/l]	500.0	445.0	405.0	**955.0**	**828.0**
Fats and oils	[mg/l]	40.0	**291.0**	**294.0**	**79.0**	**279.0**
Detergents	[mg/l]	10.0	0.268	0.257	0.366	0.384

The main characteristic of the waste water generated in the production process is the high load of the total fats and oils, ortho-phosphates and the parameters of microbiological contamination. In a number of the analyzed samples the measured values of pH are above the allowed value, which indicates to ts alkaline character. Other parameters which exceed the allowed concentration are: organic matter (COD, BOD_5), suspended solids and sediment matter (Table 2, Table 3).

Table 3. The results of waste water in dairy "B" in Kragujevac in 2016.

Parametar	Unit	Allowed value	Quantity / Description			
			I quarter	II quarter	III quarter	IV quarter
Temperature	[°C]	<35	21.1	17.0	19.0	22.0
Appearance	[-]	-	Milky White	Muddy	Muddy	Pale yellow
pH	[-]	6.0-9.0	**9.46**	**11.0**	9.0	**11.27**
Ammonia	[mg/l]	15.0	0.06	0.2	0.17	0.3
Ortho-phosphates	[mg/l]	1.0	**4.728**	**25.926**	**2.778**	**13.457**
COD	[mg O_2/l]	450.0	**1298.0**	182.0	198.0	277.0
BOD_5	[mg O_2/l]	300.0	**1104.0**	154.0	168.0	235.0
Suspended solids	[mg/l]	500.0	97.0	136.0	**618.0**	**823.0**
Fats and oils	[mg/l]	40.0	**66.0**	22.0	**860.0**	**154.0**
Detergents	[mg/l]	10.0	1.216	0.528	0.623	5.24

2.5. Best methods for waste water treatment

In the context of the BREF documents [16] can be found the best available techniques related to the waste water treatment of the food industry and thus the industry of milk and dairy products (BAT techniques).

Best BAT techniques that are used in industry of milk and dairy products and can be applied for purification of waste water are [16]:

- determining the amount of solid substances in installations;
- removing grease using scavengers of fat, if waste water containing fats of vegetable or animal origin;

- use of a flow meter and an identification of physical and chemical features of all the waste water;
- application of neutralization in a strongly acidic or strongly alkaline waste water;
- applying sedimentation for waste water that contain large amounts of suspended solids;
- application of dissolved air in flotation process;
- application of biological treatment (aerobic and anaerobic);
- the use of methane (CH_4) for producing electrical or thermal energy from the anaerobic digestion process.

When is required additional waste water treatment, in order to achieve the necessary emission limit values, the following techniques are available [16]:

- nitrogen removal by biological means;
- application of rainfall in the removal of phosphorus, simultaneous with active sludge treatment in the places where it is used;
- use of filtration in the polishing stage of waste water;
- removal of hazardous (priority) substances;
- implementation of membranes in filtration process.

When the waste water quality is good enough for re-use, BAT is recommending to apply first sterilization and disinfection, as well as avoiding the use of active chlorine to fulfilling the Directive 98/83/EC, from 1998 [16].

In the same document, there are defined the best techniques for treatment of sludge from waste water. Among these techniques are [16]:

- stabilization;
- thickening;
- drainage;
- drying, if the heat from the installation can be used.

3. CONCLUSION

Industry of milk and dairy products is highly sensitive branch of the food industry in terms of waste water. As noted above, although there are clear regulations and laws that must be respected, dairies in Serbia are mostly not complying with applicable law. Waste water is discharged, often without any prior treatment, and those plants that have some sort of system for waste water treatment in most cases cannot achieve processing of limit values for emissions of pollutants in waste water. Existing facilities are outdated and with lower capacity. The current situation requires large investments and harmonization of legislation with EU regulations in this sector. Regardless of the fact that there are many causes for this situation (awareness, competence, economic factors, political situation, market situation), all this reflects on environment and requires constantly educating, training, awareness-raising and the continuous monitoring of parameters that affect the environment.

Acknowledgements

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