Desalination and Water Treatment
www.deswater.com
doi: 10.1080/19443994.2014.986529

57 (2016) 3466–3472
February

Taylor & Francis
Taylor & Francis Group

Application of fat trap for the wastewater treatment in margarine production

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Received 10 March 2014; Accepted 7 November 2014

ABSTRACT

Wastewater from margarine production must be treated in a way and up to a level that will not pose a source of pollution before releasing into the recipient. The quality of effluent which can be discharged into the recipient is regulated by appropriate standards or regulations for every community. This paper presents the results of the application of a fat trap for wastewater treatment in a margarine production line in Serbia, in order to meet local regulations for wastewater quality and reduce pollution. Research was based on quarterly sampling performed during a period of 2.5 years. The wastewater after the treatment had a load with maximal measured concentration of TFM:39 mg/l, BOD_5:100 mg/l, COD:115 mg/l and TSS:118 mg/l. The study demonstrated that a very simple technical solution such as a fat trap could give satisfactory results that are within the national standards.

Keywords: Wastewater treatment; Fat trap; Margarine production; Fat, oil and grease (FOG)

1. Background

Margarine is a water-in-oil emulsion and consists of at least 80% fat and at most 16% water [1]. Therefore, margarine production basically involves the of oil phase and water phase where oil and water are carefully mixed through proportioning systems. The resultant mixture passes through a pasteurizer and then through a chilling unit, where it is cooled to cause emulsification and crystallization (Fig. 1).

Similar to the other food- and milk-processing industries, margarine production industry consumes large quantities of water [2]. Water is used in various processes and subprocesses of margarine production as a raw material (part of the final product). It is also used for different heating and cooling processes (in any process of pasteurization after heating, the product is cooled to the required temperature), cleaning and cleaning-in-place (CIP) processes.

Major causes leading to wastewater accumulation in margarine production plant are:

(1) Frequent cleaning of the water-phase preparation area, including raw material storage, pasteurization device, intermediate storage vessels, pipework and floors.
(2) Cleaning and rinsing with caustic-based detergents and water. This includes all processes in plant and pipework upstream and downstream of the two-phase mixing point.
(3) Range of low-volume streams such as the water phase of oil recovery from returned product, condensate and oil storage area surfaces [3].

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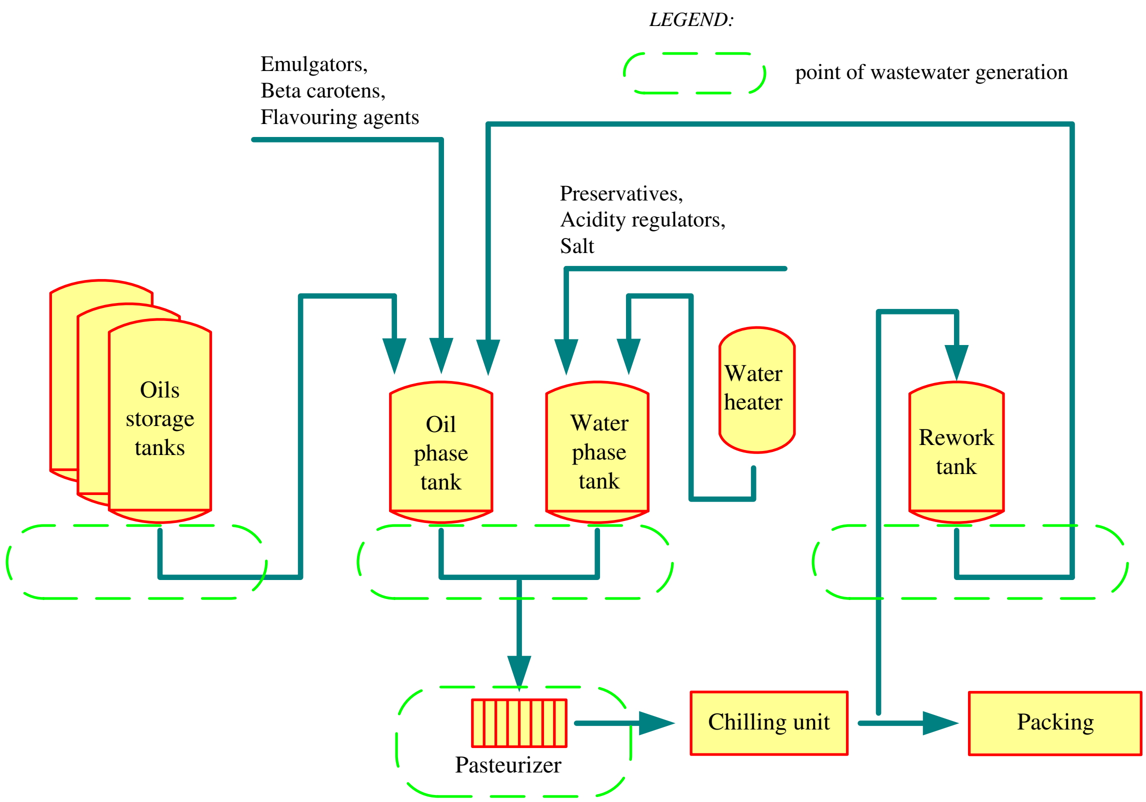

Fig. 1. Margarine production process.

The wastewater discharged from the production process has increased concentrations of fat, oil and greases (FOG). Formation of oil layer in wastewater causes significant pollution problems such as reduction of light penetration and photosynthesis [4]. FOG has negative impacts on wastewater collection and treatment systems. Most blockages in wastewater collection systems can be traced back to FOG. The blockages can increase cleaning frequency or cause replacement of piping systems, as well as unpleasant odours, sewage spills, manhole overflows or sewage backups [5].

Pollution control measures for wastewater treatment are normally undertaken from one or more of the following reasons:

(1) Reduction of water consumption by the recycling of purified effluent to process operations which do not demand high-quality water.
(2) To meet the standards issued by the appropriate authorities for discharge into their sewerage system or to a recipient.
(3) Recovery of materials for reuse or for use as byproducts with a saleable value.
(4) To reduce the trade charges on the effluent which are levied by the municipal authorities to cover the cost of off-site treatment and disposal [6].

Conventional treatment methods of fatty wastewater include gravity method, flotation, chemical treatment, biological treatment and membrane purification. One of the gravity methods uses fat (grease) traps (Fig. 2). Advantages of this method are:

(1) Easy installation, handling and maintenance.
(2) It is not affected by high or low temperatures.
(3) High static load capacity (possibility of installing under traffic areas).
(4) Long operational life [6].

The method of using fat trap is based on a simple, but very effective physical process: when influent loaded with oil and fat goes inside a separator, its velocity decreases, which allows oil to float on the surface. Fat trap configuration allows the movement of water below the fat, which provides the space above the water for collecting fat. Multi-chamber system has inside barriers which prevent unwanted flows. The speed of wastewater should be low, since separation process takes place under the force of gravity.

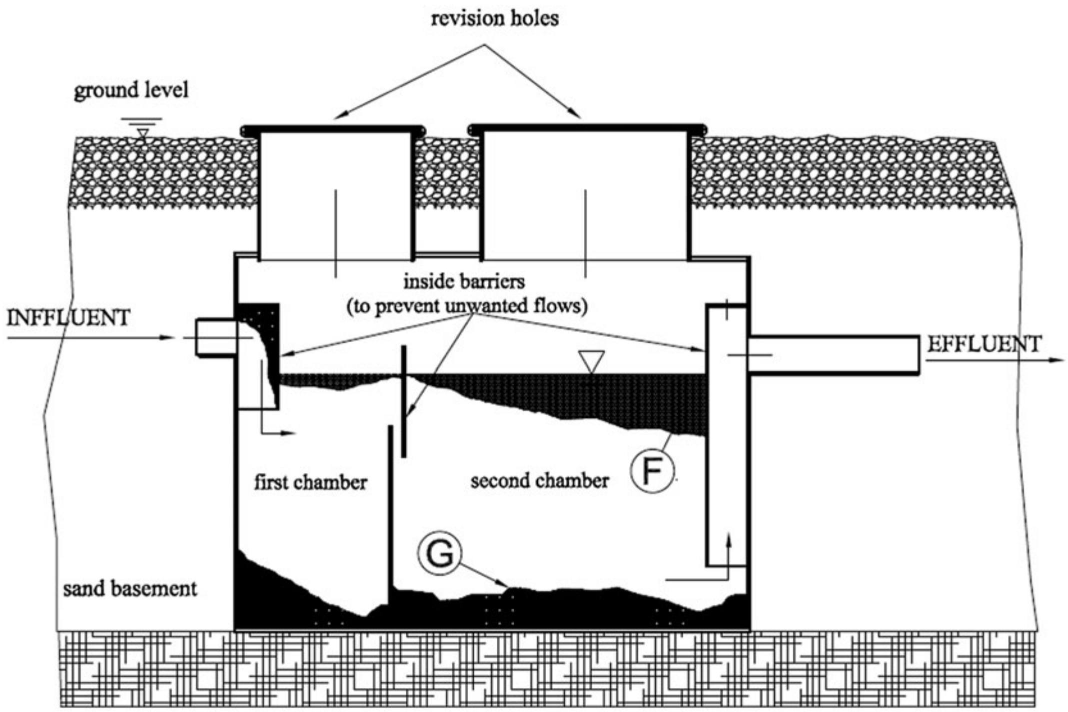

Fig. 2. Fat trap operation principles.
Note: F—accumulated FOG; G—accumulated solids

The floating solid fat must be removed from the surface of the fat trap or/and flotation pool before discharging treated wastewater. It often happens that separated solid fat layer on the surface of the pool has a thickness of a few millimetres. Usually, it is a mixture of 80% of water and 20% of grease and its removal is performed by different types of skimmers. Final effluent recipient is the city sewage.

Blowing air in the form of finely dispersed bubbles from the bottom can improve efficiency. If the water is too hot or the separator is oversized, expected results will not be achieved.

2. Materials and methods

Inspected margarine production line uses Purator FA-SF-P-SK2/A fat trap as an equipment for wastewater treatment. The fat trap has nominal hydraulic loading in the range from 0.85 to 2.15 l/s. It is a two-chamber system with a working volume of 3.3 m^3 located outside the production facility building. It is buried in the ground to avoid the influence of outside temperatures and facilitate the FOG separation on the surface.

Margarine production facility works in three shifts and 5 d in a week. Fat trap cleaning takes place on a daily basis by mechanical removal of accumulated FOG from the surface using skimmers.

The production line has automatic CIP of the closed system. It consists of a water rinse, detergent wash and water wash, so there is a potential to recycle most of the detergent and to recover wash water for use in the preliminary rinse. These are all measures that can lead to a decrease of wastewater load even before they come to a fat trap.

According to regulations for wastewater quality that are required for recipients in urban areas, it is prohibited to discharge toxic, hazardous and harmful substances in concentrations higher than the maximum residue limits (MRL). According to the regulation for wastewater quality in Serbia [7], MRL values for wastewater load are presented in Table 1.

Table 1
MRL for wastewater in Serbia

Parameter	Unit	MRL
pH value	–	6.0–9.0
TFM (totally fat matter)	mg/l	40
BOD_5 (biochemical oxygen demand)	mg/l	300
COD (chemical oxygen demand)	mg/l	450
TSS (total suspended solids)	mg/l	500

To analyse wastewater treatment efficiency of the fat trap, the analysis of the influent and effluent wastewater was made by measuring typical parameters presented in Table 1. All influent samples were collected on inlet, and effluent samples were collected on outlet of the trap. Effluent samples were chilled and transported to the certified laboratory for analysis. Parameters like pH and temperature were measured regularly on a daily basis; BOD_5 was measured by the five-d BOD test using the azide modification of the iodometric method for dissolved oxygen determination. TSS and TSM were measured by the gravimetric method. Analyses were performed on a quarterly basis by an authorized laboratory in the period from 2011 to 2013 using standard methods according to the rulebook for testing the wastewater quality [7] to determine selected wastewater properties (for pH value, TFM, BOD_5, COD and TSS standard methods used were, respectively, P-IV-6/A, U.05.81, U.05.37, P-IV-10 and P-IV-8).

3. Results and discussion

Parameters of FOG-loaded wastewater before and after treatment in specified fat trap are presented in Figs. 3–7.

Fig. 3 shows pH value declension after the treatment by the fat trap. In margarine production, wastewater is FOG loaded, so it is obvious that the pH value will be in alkaline domain. A reduction of effluent pH value compared to influent pH value in each sample can be noticed. The highest pH values

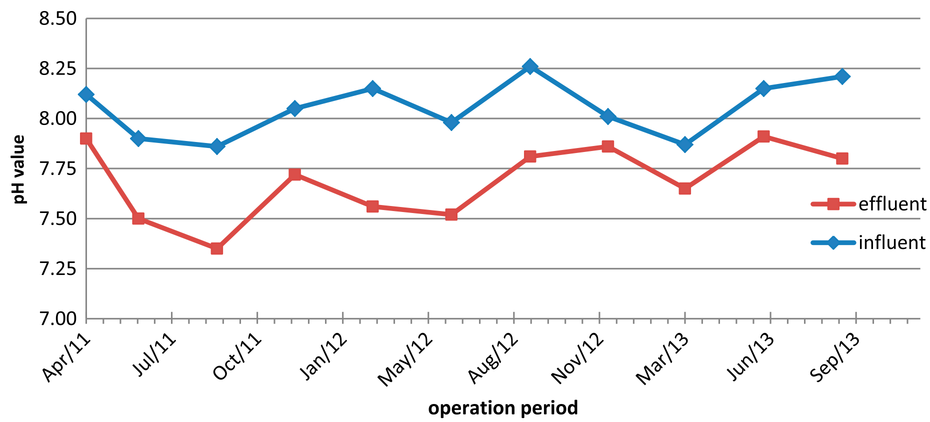

Fig. 3. pH values of wastewater influent and effluent.

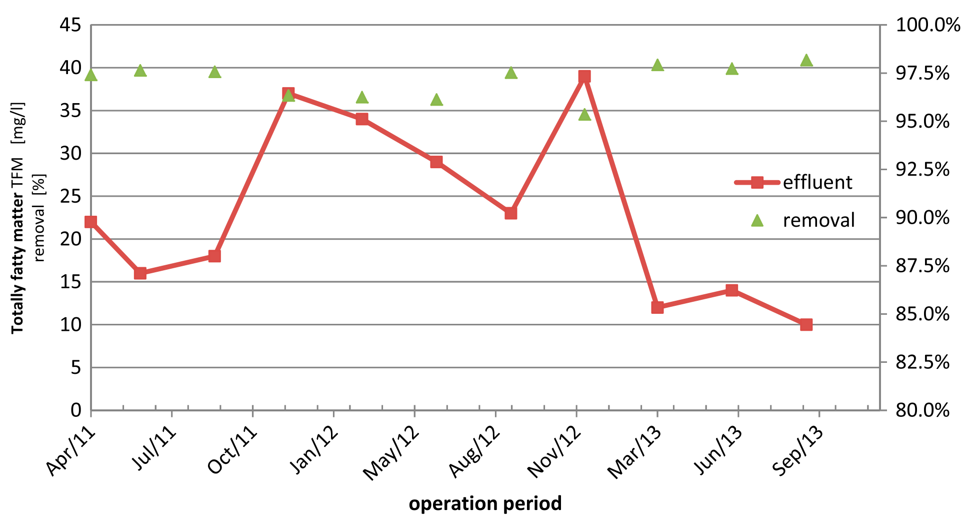

Fig. 4. TFM removal efficiency in wastewater.

correspond to the moments when sampling was done immediately after CIP (high concentration of detergents was used).

It can be noticed in Fig. 4 that TFM effluent value was below the MRL, which indicates that the fat trap successfully accomplished its main task.TFM removal efficiency increases after flotation pool cleaning, which emphasizes the importance of floating FOG removal from the surface of the fat trap. This operation must be carried out regularly, which is recommended on a daily basis. As a result of regular cleaning, very high TFM removal efficiency over the entire period of observation can be noticed (in the range from 95.36 to 98.18%). Peaks of TFM effluent were observed in winter months (December 2011 and December 2012), which leads to the assumption that low outside temperatures make TFM decomposition difficult, but even then TFM values were just below the MRL.

BOD_5 is a traditional, widely used test to establish the concentration of organic matter in wastewater

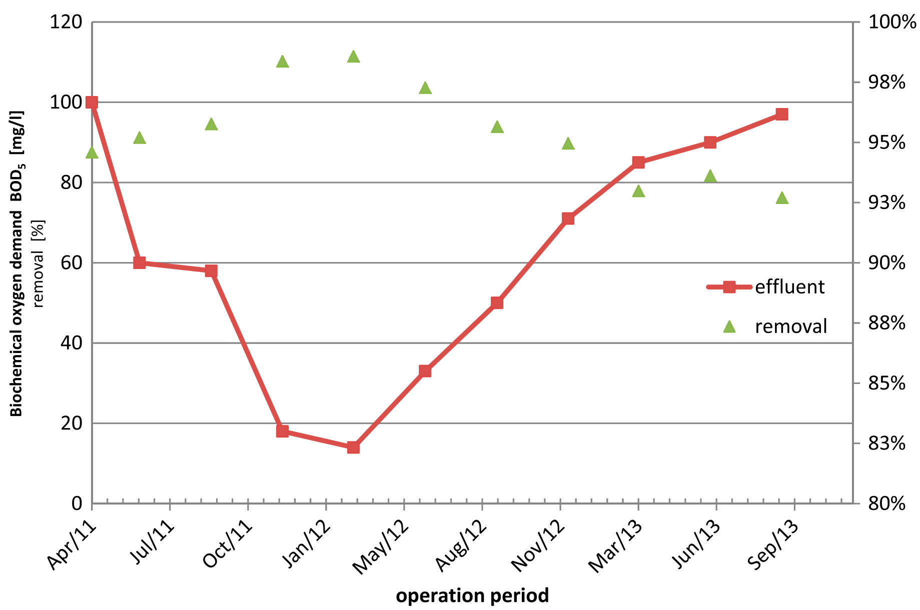

Fig. 5. BOD_5 removal efficiency in wastewater.

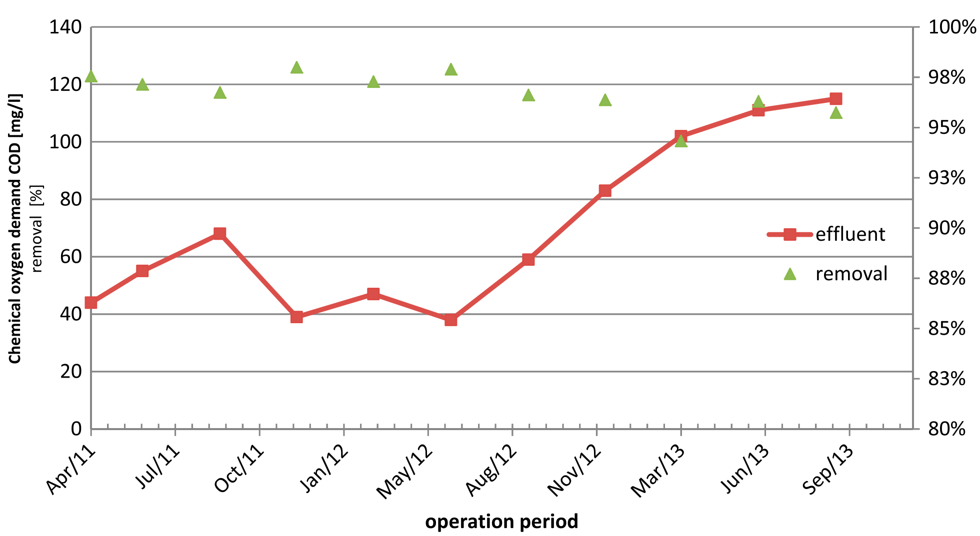

Fig. 6. COD removal efficiency in wastewater.

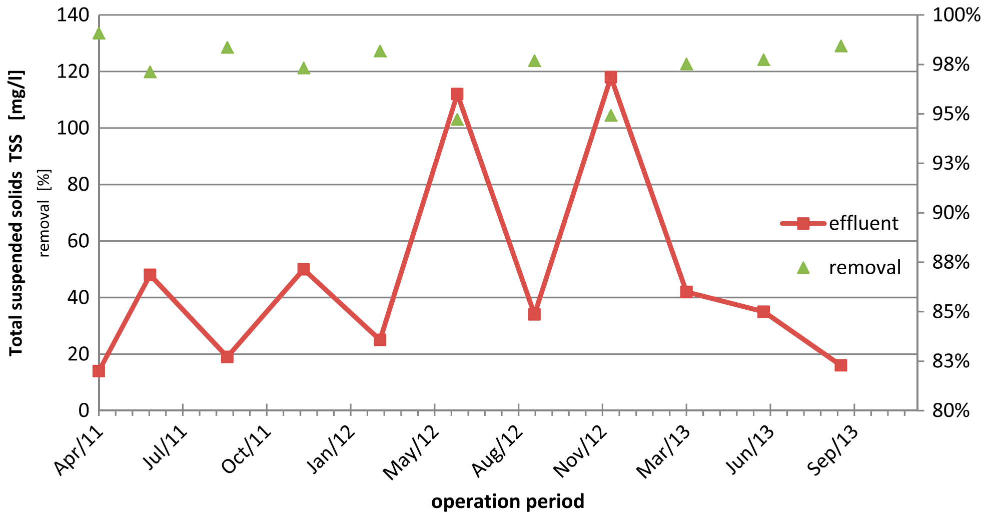

Fig. 7. TSS removal efficiency in wastewater.

samples. BOD_5 effluent values were significantly below MRL value of 300 mg/l (Fig. 5). Fat trap can be considered as a kind of holding tank for BOD_5 value removal (serial dilution procedure that allows for the stepwise reduction in concentration). The highest removal efficiency and lower value of BOD_5 effluent were noticed after the complete discharging and cleaning of flotation pool (March 2012). After this period, continuous increase of BOD_5 effluent value and continuous decrease of removal efficiency can be noticed as a result of fat trap clogging. Nevertheless, fat trap efficiency regarding BOD_5 removal is extremely high—in the range from 91.75 to 98.57%.

COD is the most popular alternative to BOD_5 for establishing the concentration of organic matter in wastewater samples because it only takes a few hours to be completed, giving it a major advantage over the BOD_5 test. Wastewater treatment system personnel can use COD as an almost real-time operational adjustment parameter. The COD test should be considered as a particular measure of the organic matter in a wastewater sample rather than a substitute for the BOD test. Industries normally focus more on COD and municipalities more on BOD_5 removal. Generally, removal of COD can be improved by chemical treatment; however, this type of treatment was not considered here. The removal efficiency of COD and COD effluent values were considerably below MRL value of 450 mg/l (Fig. 6).

Wastewater from this type of production contains large quantities of suspended solids. Most suspended solids are small particles that have the ability to clog the small pore spaces of a fat trap.

TSS effluent values were significantly below MRL value of 500 mg/l (Fig. 7). The lowest TSS removal efficiencies were recorded in June and December 2012. These measured results indicate that there was a clog of separator but it had no impact on final removal capacity. Peaks may indicate cleaning irregularity, i.e. the situations that FOG pieces are brought to the sample which make impact on the result of analysis. Filtration of water samples before sending them to the laboratory was suggested as the improvement measure.

Average values obtained from the measurements are presented in Table 2. They are in the range with results from two other branch companies that use similar wastewater treatment method. Besides, all monitored effluent parameters are below MRL.

Table 2
Parameters of waste water in branch margarine companies

Country		Hungary	Spain	Serbia
Influent	Units	Average values		
pH value	–	7.8	6.5	8.05
TFM	mg/l	–	–	769
BOD_5	mg/l	5160	1309	1297
COD	mg/l	9450	2662	2077
TSS	mg/l	1850	719	1615
Effluent				
pH value	–	7.2	8.5	7.69
TFM	mg/l	–	–	23
BOD_5	mg/l	54	40	63
COD	mg/l	87	160	65
TSS	mg/l	9	80	47

4. Conclusion

The presence of oil and fat in wastewater flow leads to the formation of FOG surface layer and it causes significant pollution problem. Analysed parameters in the wastewater in margarine production exceed the limits of MRL. This indicates the need for proper treatment using one of several available technologies. Even very simple technical solution such as a fat trap can give satisfactory results that are consistent with a regulation. Wastewater can be successfully treated with a fat trap only if all relevant parameters such as the flow of effluent, oil and fat concentration, proper and regular cleaning and maintenance of the equipment, are taken into account.

Abbreviations

TFM	—	totally fat matter
BOD_5	—	biochemical oxygen demand
COD	—	chemical oxygen demand
TSS	—	total suspended solids
CIP	—	cleaning-in-place
FOG	—	fat, oil and greases
MRL	—	maximum residue limits

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