Enhancement of qualitative indicators on biological treatment of food wastewaters based on some advanced leading systems APEPUR (Stage I)

Stage I scientific report – abstract

In order to comply with the objectives of CEEX – MENER grant no. 717/24.07.2006, Stage I, the following activities have been accomplished:

Objective no. 1. The analysis through direct measurements of food processes (i.e. milk, beer industry etc.) and the correlation of wastewater composition with technological steps; the establishing of mathematical models for different wastewaters based on numerical simulation.

Activity I.1. Wastewater sampling from food factories.

For a correct characterisation of wastewaters, a sampling programme has been settled, this being correlated to viable standards. The steps of the sampling programme were:

- the selection of sampling equipment;
- the establishing of sampling points;
- the establishing of sampling frequency, time and duration;
- the selection of sampling method;
- samples preservation, transport and storage.

Wastewater samples were taken from a beer factory, a milk factory and a unit of bread yeast processing.

To comply with the economical agents confidentiality, the following notation has been done:

- Beer factory A – sampling from sewages of brewing, fermentation, bottling and a generalised sewage;
- Milk factory B – sampling from sewages of milk reception, butter processing and a generalised sewage;
- Bread yeast processing unit C – sampling from the input and output of the wastes treatment unit – the unit is used for a partial treatment of wastewater to allow the discharge in running waters.

Activity I.2. The identification of polluted substances which have to be removed from beer, milk and bread yeast wastewaters – the sources and limit values of wastewater contaminants are briefly presented.

Beer wastewaters could be concentrated when come from different technological stages and diluted when are formed by spaces, tanks, piping and packaging washing water. Therefore, concentrated wastewater, which represents maximum 0.5% of total output, contains 24% of organic charge expressed as BOD_5.

Label removal during bottle washing increases a lot the quantity of suspended solids in wastewaters. These wastewaters have harmfulness effects similar to domestic wastewaters.

Beer wastewater treatment consist on their passage over a sieve and a decanter, followed by acid neutralization using lime. These wastewaters can be used to irrigation or can be subjected to biological treatment by aerobic processed based on active sludge and anaerobic processes after mixing with municipal wastewaters.

Important losses of dry weight in removed wastewaters take place during milk processing. Due to their composition (proteins, lipids, lactose) milk wastewaters can not be removed to sewage before a purification step in order to avoid environment pollution.

Milk wastewaters are formed by industrial polluted wastewater, domestic wastewater from sanitary sewage and clean conventional unpolluted wastewater (water used for cooling, heating or condensed water).

Milk wastewater tretment pursues first lipids separation, than a treatment using coagulants and disinfectants. Wastewaters containing lactic acid are firstly neutralised to *p*H = 7.6–7.8. Biological treatment could take place in natural way or in biofilters or aerated basins with activated sludge where wastewaters are introduced after dilution using cooling waters.

Bread yeast wastewaters have different characteristics depending on the raw material (molasses, husks, sulphitic lyes, whey, wood hydrolisates etc.) even they also have some common parameters. Therefore, all these wastewaters have an acid character (*p*H = 4–5) and contain dissolved carbohydrates, resins, gums, organis acids.

Pretty high organic charge determines oxygen consumption in receiving water followed by unpleasant smells and microbial development. Wastewaters have also toxic effects on fish due to furfurol, resin and tannin content. The effect is increased by ammonium and phosphate salts presence due to their use during the process to ensure nutritive substances for yeast development and not consumed.

Washing waters are treated by physico-chemical methods (sedimentation, filtration etc.), all the other wastewaters are biologically treated. Natural biological tretment and biological treatment in biofilters, basins with activated sludge or biofilters with artifficial aeration could be used.

Activity I.3. Analyses and measurements acchievement of polluted substances concentration to ensure biological treatment modelling.

The analyses acheived for samples were:

- wastewater temperature (to correct to the experiment value of temeprature);
- *p*H, expressed in *p*H units;
- suspended solids content, in mg/dm^3;
- biochemical oxygen demand, BOD_5, in mgO_2 / dm^3;
- chemical oxygen demand, COD, in mgO_2 / dm^3;
- conductivity, in mS/cm;
- total nitrogen, in mg/dm^3;
- total phosphorous,iîn mg/dm^3;
- microbiological analysis with total number of colony forming units and coliform number per dm^3.

Beer factory A produces beers from malt, water, yeast and hop, using unmalted cereals for some assortments: barley and/or corn. The report presents the average of results for all the measurements in graphs and comments, the main conclusions being as follows:

- The *p*H values vary around neutral value but, regarding the removal possibility in receiving waters (*p*H = 6.5–8.5), wastewater from brewing has a lower *p*H; this wastewater can be removed only after mixing with other wastewaters;
- Suspended solids have average values lower than normal values (560–900 mg/dm^3). Comparatively, they are higher for wastewater from brewing and bottling. Brewing wastewaters came from equipment washing: mash vessel, lauter tun (including the last husk washing water) and wort boiling, whirlpool, cooler, rotapool; the wastewaters contain grist fine particles, mash and wort residues removed from equipment during washing. Wastewaters from bottling contain an average of 205–210 mg/dm^3 suspended solids due to cellulose coming from labels removed in the bottling washing machine. The washing machines are usually equipped with rotative sieves able to retain the labels from cleaning agent and remove them separately but sometimes the paper of labels has a lower quality and they could be disintegrated inside the washing solution, a huge amount of cellulosic fibers being able to pass into the wastewater. The other wastewaters have low values for suspended solids explained by the high volume of water used for cleaning and cooling in fermentation and filtration units, this leading to a huge dilution – these wastewaters could be removed through municipal sewage.
- All samples are characterised by BOD_5 lower than maximum limit of 4 820 mg/dm^3, wastewaters from filtration and generalised sewage having values lower than 24 mg/dm^3.
- Chemical oxygen demand COD–Cr has the same evolution as BOD_5, higher values being obtained for brewing wastewater (an average of 880 mg/dm^3), followed by bottling wastewaters with a COD–Cr value around 400 mg/dm^3.
- The values of average conductivity are closed each other and inside the limits interval;
- Total nitrogen content and total phosphorous content are also higher in brewing and bottling wastewaters, the values are correlated with suspended solids and BOD_5 but lower than allowed limits.

The analyse of measured parameters demonstrates that brewing and bottling wastewaters have higher polutants content and have to be subjected to partial treatment before removal into a receiving water or to the municipal sewage.

The values are lower than those possible due to a technological discipline rigorously maintained and to a high water consumption to clean the equipment and spaces, this leading to a wastewater dilution and decreasing of quality parameter values.

The price still low for drinking water in Romania and the incomplete legislation regarding the environmental protection allow this thing. Therefore, many producers, to avoid the fines possible if they remove some wastewaters with high values of the quality indicators, choose to dilute them and consume impressive quantities of drinking water but do not invest in wastewater treatment units.

The aseptic conditions for sampling and the transport and storage conditions were ensured for the microbiological analysis. The microbiological parameters analysed were:

- *The total number of mesofile aerobic bacteria* – an indicator which reflects the organic contamination level of wastewaters.
- *The total number of coliforms*, including faecal coliforms, an indicator which reflects the contamination of wastewater with faecal.

The total number of mesofile aerobic bacteria could be correlated to BOD_5 indicator, this showing the intensity of biodegradative processes of organic pollutants.

On the other side, the ratio BOD_5/COD gives indications on the organic pollutants biodisponibility to be transformed through the metabolic activity of wastewater microbiota.

It is considered that a ratio BOD_5/COD lower than 0.3 indicates the positive effects of microbiota in the biodegradation process:

Correlation of biological processes responsible by the transformation of wastewater organic pollutants as a function of pollution degree and zymogene microbiota activity

Sample of wastewater	Brewing	Fermentation	Bottling	Centralised sewage
BOD_5/ COD-Cr	0,37	0,33	0,33	0,63

The contamination spectrum of wastewaters with coliformas is different from that of mesofile aerobic bacteria, being higher for brewing wastewater.

As a conclusion, beer wastewater contamination with zymogene bacteria is associated with the organic charge and the organic pollutants biodisponibility in the biodegradation process. The presence of coliform of faecal origin in samples analysed fron different points shows the hygiene-sanitising status of washing waters, correlated to the spaces, water and packages hygiene.

Milk factory B processes raw milk to produce milk for daily consumption and butter but produces fermented dairy products when there is demand. The average results of samples for the whole period of experiments are presented as graph and comments inside the report; the main conclusions are:

- The variation of *p*H average values during the whole period do not exceed the limits 8.3–10.1 for milk reception wastewaters, 6.5–9.7 for butter processing wastewater and 7.4–9.4 for wastewater from centralised sewage;
- The content of suspended solids has higher values than for beer wastewaters but situated under the limit values for milk wastewaters;
- Biochemical oxygen demand (BOD_5), and chemical oxygen demand (COD-Mn) have lower values than the limit values admitted for milk wastewaters;
- The analysed wastewaters are very polluted but their total nitrogen and phosphorous contents are situated under standard limits established for milk wastewater;
- Analysing the pollution degree and biochemical and chemical oxidising capacity of the organic compounds, a high biodegratation potential of wastewater is obtained - this explains the organic compounds disponibility to be oxidised on biological way and the zymogene microbiota potential to transform organic pollutants;
- The small value of BOD_5 for butter processing wastewater in comaprison with other values can be explained by the presence, in the technological process, of lipolytic microorganisms only, these having a limited biodegradation potential. This fact is shown by the ratio BOD_5/COD-Mn:

Biochemical oxidised degree in milk processing wastewater compared to chemical odydation

Sample of wastewater	Milk reception	Butter processing	Centralised sewage
CBO_5/ CCO-Mn	0,65	0,37	0,53

The reason could be the presence of microorganisms with limited biodegradation potential or the existence of environmental conditions unfavourable for degradative processes (substrate, oxygen presence or absence, low temperatures or pH values outside the optimal limits).

The high value of ratio BOD_5/COD for milk reception and centralised sewage wastewater is probably determined by the low velocity of biochemical oxidation due to alcaline *p*H values (9.5 and 8.2) influence on zymogene microbiota which consists mainly in lactic bacteria.

The ratio BOD_5/COD has the lowest value for butter processing wastewater, this being explained by the microbiota specificity to transform the substrate, correlated to *p*H value (6.7), the microorganisms activity being facilitated (lactic bacteria, fungi).

As a conclusion, milk processing wastewaters vary in composition due to origin / sampling point. Organic compounds biodisponibility and zymogene microbiota biodegradation potential are correlated to qualitative and quantitative variation of microbiota and to physico – chemical factors of the environment (*p*H, temperature, dissolved oxygen etc).

Bread yeast factory C. Wastewaters coming from bread yeast processing are characterised by a high organic charge. Organic matter, containing predominantly carbohydrates, are especially dissolved in aqueous phase. The factory chosen for study uses as raw material molasses from sugar processing units, therefore, as a consequence, wastewaters are rich in melanoidines from molasses and a specific and quite intense colour (caramel colour).

Bread yeast factory C has a unit for partial treatment of wastewaters. The effluents from the factory are treated so they have to correspond to NTPA 002/2002 norms (quality parameters of wastewaters removed through municipal sewage) than discharged into the municipal sewage. There are plans to upgrade of the wastewater treatment unit since the production has grown and the efficient removal of organic pollutants is realised with difficulty.

The wastewater treatment unit works with lower flow rates than those designed – a compromise key necessary to ensure organic charge removal.

The wastewater treatment unit which has been designed for a flow rate input of 166.7 m^3/h and a content of pollutants of 792 mg O_2/L (COD) but the average value of COD is much higher (3 800 mg O_2/L), therefore it is necessary to reduce the flow rate to attain the final organic content imposed by norms/standards.

It is necessary to add that exhausted culture media is subjected to biological treatment only partially (around 18 m^3/zi) since it has very high organic content (COD is in between 16 000 and 26 000 mgO_2/L); this residuu is concentrated by vaporisation from 5 to 63°Bx and it is commercialised as agrotechnical fertiliser.

The values of parameters for effluents from yeast proceesing plant are high at the entrance in the treatment unit (COD = 3 800 mgO_2/dm^3). Moreover, it has to take into account that the exhausted substrate is mixed in a small ratio with the other effluents and has a higher concentration in organic substances (COD = 16 000 – 26 000 mgO_2/dm^3).

The *p*H value does not reppresent a problem since it is maintained at 7 by adding sulphuric acid during the yeast processing steps.

The values measured at the exit from the wastewater treatment unit correspond to NTPA 002/2002 norms but it is important to retain that this situation is favoured by a succession of technological compromises which have also impact on the economical profitableness as it is mentioned above.

A significant reduction of organic charge takes place in the wastewater treatment unit (89.47% for COD and 84.49% for BOD). The nitrogen content is also removed in a percentage of 86.38%, and total suspended solids are reduced with 61.05%. The phosphorous value in the output flow rate is very small (even under the NTPA limit) due to its small value in the wastewater, sometimes being necessary to add phosphorous acid to a successful treatment.

As final conclusion, the three types of wastewater have to be subjected to an aerobic biological treatment which is more efficient in correlation with their medium organic content.