# Efficiency and Limits of Physicochemical Treatment of Dairy Wastewater (Case Study: Dairy Industry in Western Algeria)

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***Abstract*****—** Environmental issues in the food industry are related to the water because it consumes water and release large volumes of wastewater.

The treatment of such discharges techniques can be adapted to different situations encountered. For dairy effluents, it is necessary and very effective to use a treatment that eliminates much of the pollutant load, thus, to drastically reduce the organic loading rate.

This study aims to evaluate the Efficiency and limitations of physicochemical treatment by coagulation - flocculation of liquid effluent from this type of food industry in Algeria, to give an example of the type and the degree of pollution generated by this sector and in order to reduce pollution and minimize its environmental issues.
Coagulation - flocculation-sedimentation was carried out using lime, the flocculation process is performed without additive use (flocculant), and it is carried out under the influence of gentle agitation. The processing efficiency is indicated by the concentration of pollutants in treated water.

The results show that treatment is not sufficient to remove organic pollution, but it has significantly reduced the Total Suspended Solids (TSS), nitrate ($NO_3$-N) and phosphate ($PO_4$-P).

***Keywords*****—** Algeria, Coagulation-flocculation, Dairy effluent, Treatment.

## I. Introduction

THE purification techniques agro industrial waste can be adapted to different situations encountered.

For dairy effluents, it is necessary and very effective to use a treatment that eliminates the most of the pollution load, to reduce the biological oxygen demand residual (BOD) and chemical oxygen demand (COD).

Generally, biological treatment is given to the treatment of dairy waste because the nature of the spill is primarily biodegradable organic [1].

the activated sludge treatment plants are powerful channels unsuitable because of the economic situation, their investment and operating costs are prohibitive for the artisanal sector.

The need of a processing solution.

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The physico-chemical treatment by coagulation-flocculation-decantation is a widely used treatment, it is applied directly to the raw water, it is one of the most important processes in water treatment systems [2].

The objective of this study is the evaluation of the performance limitations of treatment of the global crude dairy effluent by coagulation-sedimentation using lime which is considered a very common coagulant [3, 4, 5] without the addition of additives (flocculants).

The processing efficiency is indicated by the concentration of pollutants in the treated water.

## II. Materials And Methods

The waste water sample was taken from the municipal sewer system, receiving raw dairy effluent discharged, located immediately off of the unit called indistrielle Giplait-Source.
Treatment with Coagulation-Sedimentation was performed using a jar test device JF / 4 model, ISCO, Milan, Italy.

The tested coagulant is slaked lime (calcium hydroxide), Ca $(OH)_2$, the product used is a commercial made by Arcelor-Mittal. It is obtained by slaking of the burnt lime with greater than 95% purity.

Different Coagulation Sedimentation tests were performed on the sample to be studied at a temperature of 25 ± 2 ° C (temperature in the laboratory) according to the following experimental protocol:

In a series of beakers containing 500 ml of dairy wastewater is introduced the coagulating agent (lime $Ca(OH)_2$) at increasing doses: 0mg / l 100 mg / l 400 mg / l and 800mg / l, for a short period of stirring (3 min) but a fast agitation speed (150 rev / min) to ensure a good distribution of the adjuvant and good chemical destabilization of colloids. The coagulant is used in solid form without dilution or dissolution.

Gently stirred (30 rpm) for 20 min to promote the contact of particles and avoid breaking the flocs formed. The stirring blades are then gently removed and the samples were allowed to settle for 90 minutes.

After settling, were removed carefully to each beaker, a sample for analysis.

The measured parameters are: COD, the Total Suspended Solids (TSS), nitrate ($NO_3$-N) and phosphate ($PO_4$-P).

## III. Result And Discussion

The treatment efficacy was evaluated analytically by monitoring the rate of reduction of the COD, TSS, ($NO_3$-N) and ($PO_4$-P) using the initial and the final concentration of each element in the dairy wastewater. The results are summarized in Table I.

TABLE I
EVOLUTION OF THE CONTENT OF : COD, TSS, $NO_3$-N, $PO_4$-P DEPENDING ON THE CONCENTRATION OF LIME

| [Ca $(OH)_2$](mg/l) | *0* | *100* | *400* | *800* |
|---|---|---|---|---|
| DCO ($mgO_2$/l) | 1023 | 735 | 674 | 577 |
| *reduction%* | *00* | *28* | *34* | *43.6* |
| TSS (mg/l) | 406 | 24 | 11 | 09 |
| *reduction%* | *00* | *94* | *97.3* | *97.8* |
| $NO_3$-N (mg/l) | 27.9 | 25.25 | 9.5 | 0.5 |
| *reduction%* | *00* | *9.5* | *66* | *98.2* |
| $PO_4$-P (mg/l) | 0.69 | 0.1 | 0.09 | 00 |
| *reduction%* | *00* | *87* | *85.5* | *100* |

### *A. Reduction of Chemical Oxygen Demand (DCO)*

The results obtained show that the optimal coagulation dose corresponds to 800 mg / l Ca $(OH)_2$ (Fig 1). This indicates that the organic materials are removed giving COD reduction capacity of around 43.6%, an average rate that can be explained by the presence of the soluble fraction representing 1/3 of the total COD.

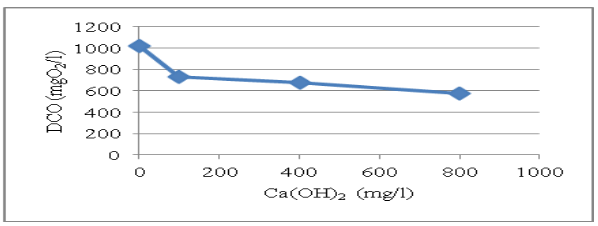


Fig.1 COD variation depending on the concentration of Ca $(OH)_2$

### *B. Reduction of TSS and Nitrate $NO_3$-N*

The removal of TSS and $NO_3$-N is almost total.
The addition of lime leads to reductions rates of 97.8 and 98.2% respectively, again for the optimum dose of coagulant: 800mg / l (Fig 2 and Fig 3).

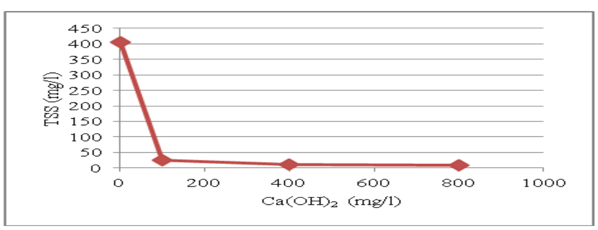


Fig.2 TSS variation depending on the concentration of $Ca(OH)_2$

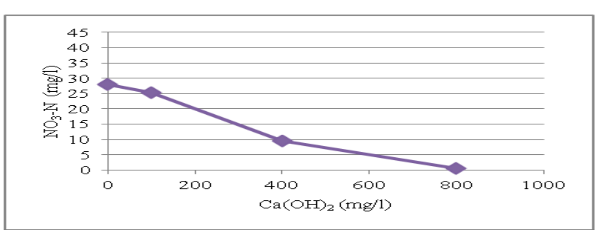


Fig.3 $NO_3$-N variation depending on the concentration of Ca $(OH)_2$

### *C. Reduction of $PO_4$-P*

Lime has proven effective in removing phosphates, The amounts of Ca $(OH)_2$ added led to very high turnover rate phosphates, which exceed the 80% to 100% for optimal dose 400 mg/l (Fig 4).
The addition of lime in the waste water to be treated leads to the precipitation of calcium dihydrogen phosphate with an optimum pH of 6 to7 according to the following reaction [4]:

$$2\,H_3PO_4 + Ca\,(OH)_2 \rightarrow Ca(PO_4H)_2 + 2\,H_2O$$

This compound decanted fairly quickly but has a high residual solubility. An excess of lime until a pH of 9 to 12 results in the precipitation of the tricalcium phosphate, as shown in the following chemical reaction [4]:

$$2\,Ca\,(PO_4H)_2 + Ca(OH)_2 \rightarrow Ca_3\,(PO_4)_2 + 2H_2O$$

For our test, improving the removal of phosphates can be explained by the precipitation of $Ca_3\,(PO_4)_2$.

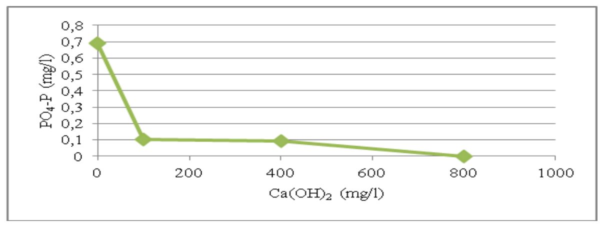


Fig.4 $PO_4$-P variation depending on the concentration of $Ca(OH)_2$

The contents obtained after the chemical treatment are consistent with Algerian values set for industrial liquid discharges in the receiving environment (Fig 5, 6 and 7),

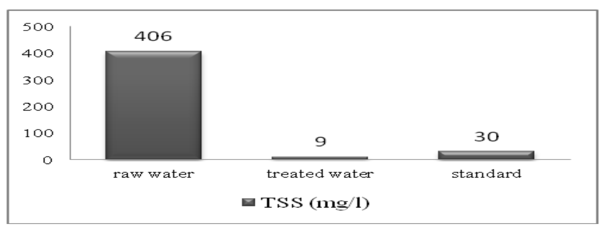


Fig 5 TSS of the dairy effluent before and after treatment

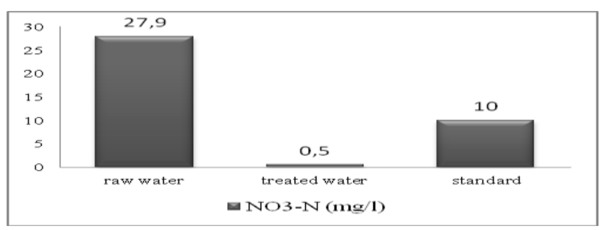


Fig 6 $NO_3$-N of the dairy effluent before and after treatment

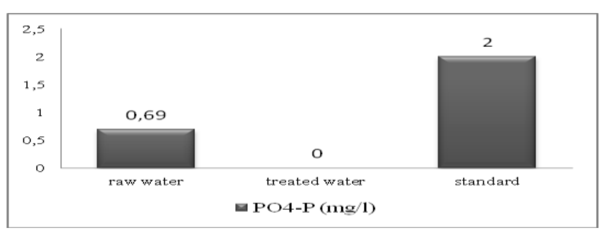


Fig 7 $PO_4$-P of the dairy effluent before and after treatment

Except for the chemical oxygen demand COD or content always remains above the norm (Fig 8).

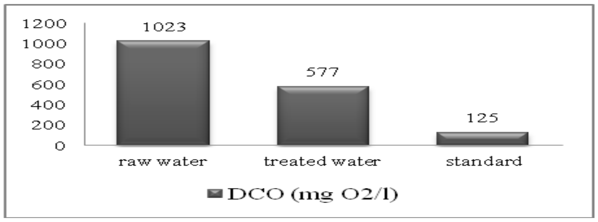


Fig 8 COD of the dairy effluent before and after treatment

It appears that the Coagulation-Sedimentation can be used as a pretreatment step, it will be necessary to conduct additional biological treatment to effectively remove organic matter in the effluent.

### *D. Recovery of sludge generated during the treatment of Coagulation-Sedimentation*

Coagulation-Sedimentation of dairy effluent with lime allows rejecting less pollution into the environment, but it generates a physicochemical sludge to be dried and removed thereafter.

Knowledge of the physical, chemical and bacteriological quality of this product is therefore essential before suggesting any possibility of treatment.

It is obvious that these coagula contain particulate and colloidal fraction settle able removed to the dairy waste water including organic matter, nitrogen and phosphorus but also a quantity of chemical reagent (lime) in the form of precipitate . The composition of the sludge therefore some agricultural wealth that could be valued at two levels: an organic soil and mineral fertilizer value that can enrich and supplement the reserve of soil and used to plant nutrition. Previous work [6] indicated that the solid phase dairies sludge is rich in organic nitrogen compounds including mineralization in soil is very gradual and that 60 to 90% of this nitrogen is transformed into mineral nitrogen quickly assimilated by plants.

The sludge from the treatment of dairy effluent are either free of toxic substances, or the latter are present at levels below the limits of the AFNOR U44-041 [6, 7, 8, 9].

The absence of phytotoxic is in favor of an agricultural use seems to be the obvious solution for this type of sludge provided you follow the recommendations of spreading sludge (which spread? Which season? At what dose ? Nature of cultures? Technical implementation? etc.).

According to Hassan et al. [10], the bacterial load contained in waste water is always removed and concentrated in sludge, representing a potential risk for possible valuation for agriculture, hence the need to refine sludge.

In this regard, note the happy effect of liming of the treated effluent, resulting in a rise in pH and therefore stopping bacterial growth and inhibition of fermentable power of the sludge. In addition, liming enhances the ability of the sludge to undergo mechanical dewatering.

## IV. Conclusion

The environmental problems of the dairy industry are related to the water because it rejects large volumes of wastewater with variable pH and rich in organic matter and bacteriological.

The study of the physicochemical characterization of the slag rejection revealed its richness in organic matter expressed in terms of chemical oxygen demand COD, in terms of biochemical oxygen demand BOD, suspended solids, nitrates and also far beyond for certain parameters, the discharge standards values set by the Algerian legislation.

Coagulation-flocculation treatment trials with lime, though insufficient vis-à-vis the elimination of organic pollution, the optimal abatement rate rarely exceeds 43.60%, has significantly reduced the material suspended (97.78%), nitrates $NO_3$-N (98.21%) and phosphate $PO_4$-P (100%) and consequently to respect the Algerian standards for these three parameters.

In order to suggest a treatment that is more effective, Coagulation-Sedimentation can be used as a pretreatment step. It will be necessary to conduct additional biological treatment.
The treatment of coagulation-sedimentation produces a sludge that forms the "waste" of purification, waste which it is important to know the composition and ensure proper disposal.

## References

[1] R Moletta, Mr. Torrijos environmental impact of effluents from the dairy sector, Tech. Ing 1999 F-1500: pp. 1-9.

[2] F Edeline . Publisher Edition Cebedo. Technical & Doc Lavoisier, 2nd edition.1992.

[3] Baptiste P., Sewage treatment before admission to a collective station. Internship report on the purification of effluents Food, Water Agency Adour Garonne 1994.

[4] S Dégremont , Memento Technical Water. Volume I. Tec. and Doc. Lavoisier, Paris, France, in 1989.

[5] Desjardin R., K. Lengo, Ndiongue S. Comparative study of the performance of various coagulants prehydrolyzed on removal of dissolved organic matter, Vector Environment 29, 1996, pp. 37-45.

[6] P Vidou, Spreading sludge from dairies treatment plants. Study published by Agency Loire Bretagne basin, Orleans, France, 1984.

[7] Agency Loire Bretagne basin, wastewater treatment in the food industry, Environment and Food Quality Productions, 1989 pp. 167-188.

[8] P. Guettier, J.P Iwema., R Mathian, D Raby, A. Vachon, P Vidou. The consolidation of centers: current treatment techniques and developments. Interagency Study No. 27, Water Agencies, Paris, France. 1994.

[9] G Sachon . Wastewater treatment des'industries Food. Symposium. Productions Food and Environment, Paris, France,1990.

[10] A Hassen , N Jedidi, H Kallali, M Ferchichi, A Gharbi, F Chebbi, A Chefai, N Saidi, H Shayeb, M Ennabli,. removal of bacterial indicators and heavy metals in treatment of domestic sewage in a semi-industrial pilot plant, Sci. Tech. Water 27, 1994, PP. 34-41.