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Characterization and Treatment of Cheese Whey Wastewater.

Nacera Lahouel[1,2]*, Omar Kheroua[1], Djamel Saidi[1], and Fatima Zohra Yahiaoui[2].

[1]Laboratory of the Physiology of Nutrition and Food Safety, Department of Biology, Faculty of Natural and Life Science, University of Oran 1, Ahmed Ben Bella, Oran, Algeria

[2]Unité de Recherche Appliquée en Energies Renouvelables, URAER, Centre de Développement des Energies Renouvelables, CDER, 47133, Ghardaïa, Algeria

ABSTRACT

Whey is the major by-product of the dairy industry, which is produced in large quantities and usually disposed off causing major environmental pollution, due to its high organic load. The objective of this work is a development of a new pretreatment and transformation of whey residues into useful organic compounds. In this study, we realize two treatments of whey; the first, a chemical treatment using sulfuric acid (H2SO4) (0.5 M) at 45C °. The second is a biological treatment using *Bacillus spp.* A total of 07 samples of whey effluents were collected within 07 days, and then were put into analysis. Results show the Whey Samples (WS) discharged from dairy processing industry was highly contaminated with organic compounds. The average values of chemical oxygen demand (COD) and Biological oxygen demand (BOD) were 1280 and 703 mg02/l. oil and grease concentration up to 8 mg/l was detected. The chemical treatment using sulfuric acid (H2SO4) has reduced 93 % of the COD, and 95% of the BOD.the biological treatment realized with Bacillus spp for a period of 30 days was less effective, reduced the COD with 54% But these two treatments of whey are equally effective in reducing of the BOD (92% reduction of BOD during 30 days of treatment). This work show that the chemical treatment using sulfuric acid proved to be effective and produced effluent characteristics in compliance within the permissible limits set by the law. The organic compounds of chemical treatment of whey represent a significant resource in particular (proteins, peptides and amino acids fatty acid monosaccharide as galactose and glucose.) which are utilizable as into an energy source. This approach paves the way towards the establishment of a bio-based economy and an effective organic residues valorization for the formation of bio-based chemicals and materials.

Keywords: Whey, environmental, pollution, biological treatment, recycling, waste, chemical, food industry.

Corresponding author

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INTRODUCTION

Nowadays environmental standards require industrial respect for the natural environment by controlling the composition of industrial waste and studying its influence on the flora and fauna of the environment. The food processing industry is faced with a problem has developed over recent years more and more crucial. It is the pollution created by waste and releases of this industry [1]. In Algeria, many food industries, large consumers of water, throw out directly their highly polluting effluents in unfit to any self treatment including drought deemed wadis. Dairy industries annually produce hundreds of millions of kilograms of milk and its derivants. Algeria is a significant development of the dairy sector, where consumption of milk and dairy products increased by 2.7 million tons in 1990 to 3.4 million tons in 2004, and the cheese production reached 1,540 tons in 2000 with an average consumption of 0.7 kg / person / year. This transformation leads to huge amounts of waste discharge which have considerable environmental problem [2]. The waste water of diary contain large quantities of milk constituents such as casein, lactose, fal, inorganic salt, besides detergents & sanitizers used for washing [3]. The worldwide production of fluid whey by the cheese and casein industries runs into millions of tons, and yet effective utilization of this material is not well developed. World annual production of whey is estimated to be 115 million tons; approximately 47 % of the produced whey is disposed into the environment [4]. Whey is one of the most typical examples of the product under processing raw material milk. This is partly due to a biochemical oxygen demand (BOD) and large on the other hand to its high sugar content [5, 6]. It also contains carbohydrates lactose, salts, lactic acid, proteins and fat, respectively [7-9]. This wealth could be used as a substrate for fermentation biotechnology for the energies production. It should be added that the whey has already been tested to be exploited as raw material for the fermentation production of various metabolites, such as citric acid, ethanol, and the production of animal feed [10]. The objective of our work is to study the biochemical and physic-chemical characteristics of the rejection of the dairy industry before and after the chemical and biological treatment in hopes of minimizing and reducing the polluting charge of WS.

MATERIALS AND METHODS

The objective of this part of the work is to study the characteristics of the effluent in the agro-food manufacture a dairy's industries, located in the province of Ghardaia to give an example of the type and degree of pollution generated by this industry.

The effluent samples were collected from Alouani dairy industry located in the region of Belghanem Ghardaia's city. Whey samples were collected and transported to the laboratory Temperature and pH were measured at the site of collection.

In the firste a Chemical hydrolysis of whey with sulfuric acid was processing This method is based on the dissolution of the components other than fatty material with sulfuric acid and separated by centrifugation with addition of a small quantity of isoamyl alcohol (3-methyl-1-butanol) which promotes the collection of the fat.

Physico-chemical characteristic of whey before and after a chemical treatment need to be found out with reference to the following parameters : The Dissolved Oxygen (DO) was determined by using the Winkler's Method [11]. Total Dissolved Solid (TDS) was determined in the laboratory using the Jenway conductmeter model HANNA. The chloride was determined by argentiometric method, The Total Solids (TS) was determined gravimetrically [12].Biochemical analysis of whey before and after chemical treatment was achieved with reference the following main

- Dry matter (solids not fat).
- The Protein Concentration: are important components dissolved in the whey because of their nutritional qualities. And on many proprieties functionally.
- The concentration of fatty material.
- Concentration of lactose: The main whey sugar is lactose, a disaccharide formed by the association of a molecule of glucose and one molecule of gelatos.
- Minerals salt

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In the second the Biological treatment of whey is realized by inoculating 2L of whey sample with Bacillus spp. This sample was incubate for 30 days at 37C° and oxygenated once per week .Aliquots were collected during incubation for the measuring of BOD and COD rate evolution

RESULTS AND DISCUSSION

This study was undertaken to detection of the important pollution parameters in dairy industry wastewater. Total 07samples of whey collected and subjected for analysis.

From collected samples mean values are taken out. The high BOD and COD values obtained by the analysis of dairy effluent indicate the presence of heavy load of organic metal **(Fig 1).** The discharge of wastewater to the environment without any treatment plays significant risk for public health and environmental pollution the industrial wastes leads contamination of the water, soil and air when they are discharged without being subject to treatment or when they are treated using inappropriate methods.

Mean values of physical Characteristics of seven untreated whey samples. such as pH, TDS and SS are 9.1, 1354 mg/L, 292.1 mg/L, respectively, and mean values of chemical characteristics such as DO, BOD, COD, Chloride, Oil and Grease are 2.1, 712.9, 1296.3, 246.1 and 2.5mg/l, respectively.

The physical and chemical characteristics of whey samples after the first treatment (chemical treatment) were:

-Mean values of chemical characteristics such as DO, BOD, COD, Chloride, Oil and Grease are 1.2, 29.6, 98.6, 87.6, 2.5mg/l respectively, and mean values of physical characteristics such as pH, TDS and SS are 6.7, 503.2 mg/lit, 80.9g/L respectively **(Fig 1 and 2)**.

The whey samples were tested for BOD, COD, DO, Chloride, Oil and Grease TSS, Sulphate and pH values before and after treatment. The results indicated that pollution parameter levels whey samples of dairy industry tested in this study was found high. To avoid the environmental pollution and to protect public health, wastewater treatment and recovery systems are recommended for dairy industry.

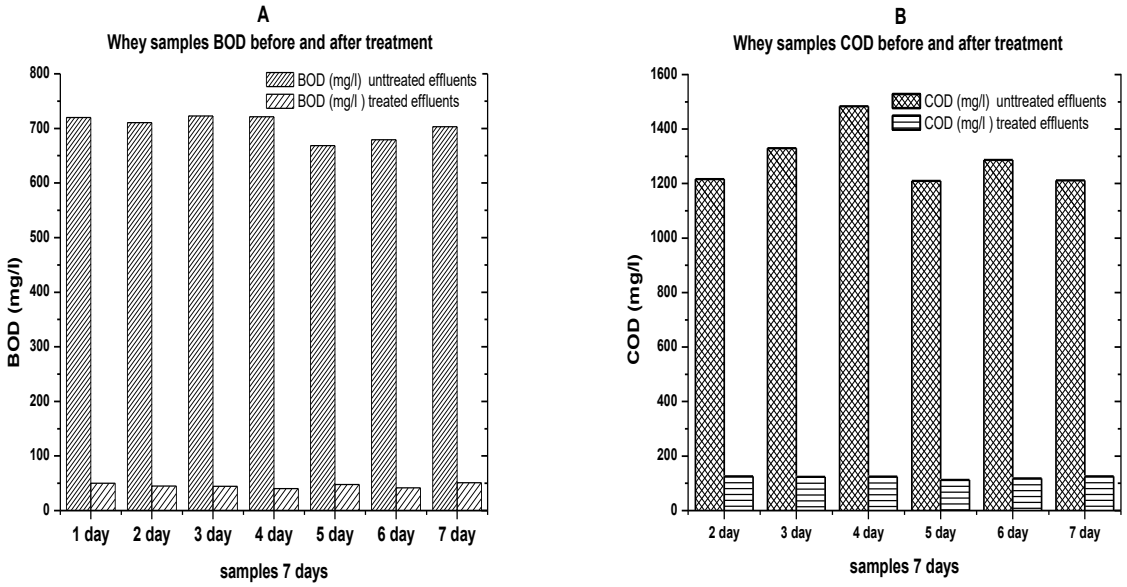

Figure 1: Rate of BOD and COD WS before and after treatment.

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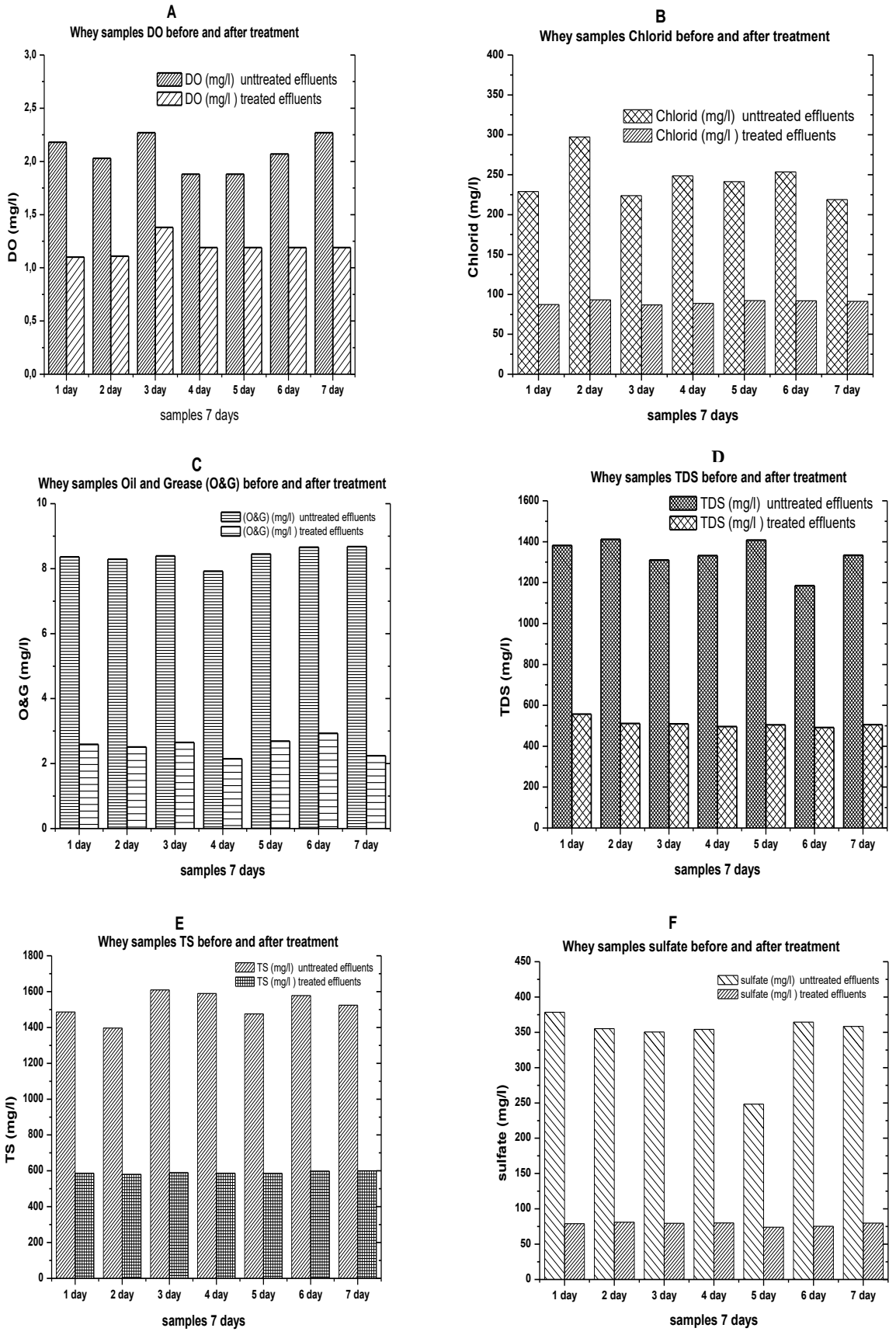

Figure 2: Physical and chemical characteristics of WS before and after treatment

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The second treatment (biological treatment) by Bacillus spp noted in the figure 3 a COD reduction of 54% after 30 days giving final values of 582 mg L-1.While Bacillus spp have reduced the BOD with 92% with a value 56 mg L-1

As shown in the figure 3, the COD remains slightly high after treatment; this verifies that a high amount of organic matter as a substrate is still present in the media. After 10 days, biomass goes into exponential phase with a very slow growth. The reduction in COD can be explained by the use of organic matter present in the media by microorganisms to meet their energy needs required for cellular biosynthesis reactions in the presence of oxygen [13]

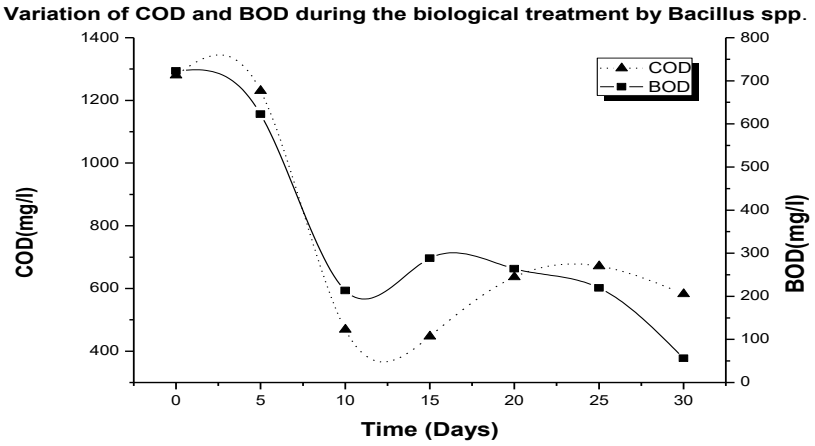

Figure 3: Variation of COD and BOD during the biological treatment by *Bacillus spp.*

So overall, a chemical treatment reduced total COD of 93% from initial effluent. However a biological treatment by Bacillus spp took 30 days to reduce the COD of only 54% [14].

So the treatment realized giving best results for BOD and COD, is still the chemical treatment using sulfuric acid.

After different treatment techniques, the dairy waste processing industry consists essentially of water, lactose, proteins, minerals and fat.

Our result shows that there is a reduction of protein levels during hydrolysis; the proteins have regions which resist hydrolysis with mineral acid. The presence of a strong organic acid was found to be efficient for hydrolysis of a hydrophobic peptide bond. The proposed condition, a 2:1 (by vol) mixture of concentrated hydrochloric acid and trifluoroacetic acid at 166 degrees C for 25 min. The method was shown to be superior to the conventional conditions, especially for hydrophobic proteins. The present method destroys tryptophan, as the conventional acid hydrolysis does (Fig. 4).

By applying Hammet's acidity function; kinetic data from all experiments were described by a single line. With concentrated inorganic acids, low reaction temperatures allowed lactose hydrolysis with minimal by-product formation and generated a hexose-rich solution amenable to fermentation.

Compounds hydrolyzed whey are therefore of great interest in economic terms, its proteins are using the can as a supplement in animal feed and exploited for their functional and nutritional properties in the food industry [15].

The lactose is converted to other compounds such as organic acids (acetic acid, propionic, lactic and succinic) or biofuel (bioethanol) obtained by microbial fermentation [16-18].

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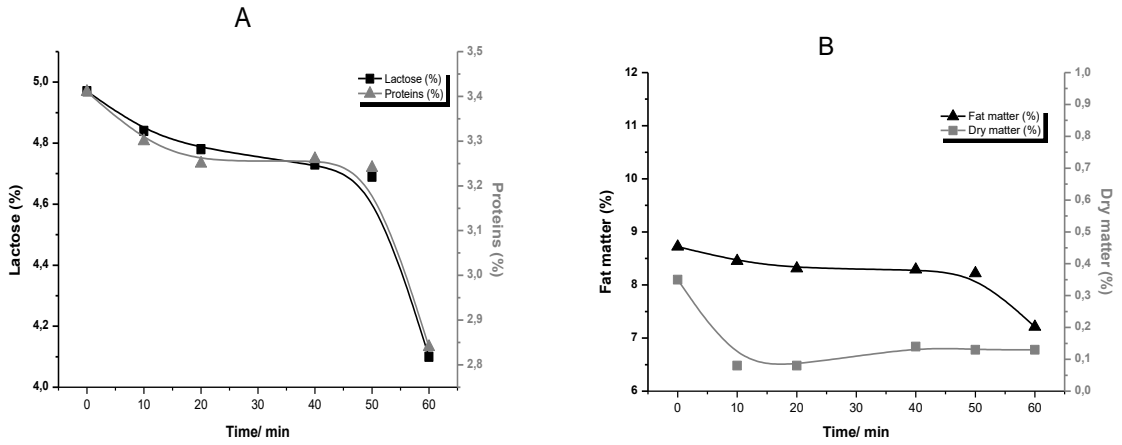

Figure 4: Kinetics of the organic compounds WS hydrolyzed with sulfuric acid (H_2SO_4) at 45C °(A) Lactose and proteins (B) Fat matter and Dry matter.

Whey represents an important environmental problem because of the high volumes produced and its high organic matter content [17]. The search for a satisfactory solution for disposal of the unutilized whey produced in the manufacture of cheese remains an area of intense concern for the dairy industry. Although adequate technology is available to recover selectively and concentrate the nutritious protein portion of cheese whey, no widely accepted method has been developed to utilize the lactose portion. Since conventional waste treatment systems are costly, the ideal solution would entail converting the lactose to a marketable product to defray the operating costs and possibly recover the initial capital outlay [2].

One alternative often proposed is to ferment the lactose into ethanol for use as a fuel or chemical feedstock. In subsequent research, we have contributed to the conversion of lactose from whey polysaccharides for value in high-energy substances. [20-22].

The options for treatment of whey can be dividing in three categories [23]:

- Those involving a fermentation step, there are many options that have been investigated such as production of biogas, biomass, ethanol, lactic acid and citric acid
- Those involving separation of the lactose and its utilization, these are probably the most attractive option.
- Those involving enzymatic hydrolysis of the lactose to produce galactose and glucose. The hydrolysis of lactose yields the sweet soluble sugars, glucose and galactose, thus increasing the applications of the product . Such hydrolysis can be carried out by treatment of whey with lactase (β-galactosidase) or by treatment of de-proteinized whey at an elevated temperature and low pH. It should be note that it is difficult to dry hydrolyzed whey, because of the tendency of the monosaccharides formed by the hydrolysis to produce glasses on the surface of the drier. Hydrolysis of lactose can be carried out by a number of processes including heat/ acid and enzymatic hydrolysis [24].

CONCLUSIONS

Wastewater from dairies and cheese industries contain mainly organic and biodegradable materials that can disrupt aquatic and terrestrial ecosystems. Due to the high pollution load of dairy wastewater, the milk-processing industries discharging untreated/partially treated wastewater cause serious environmental problems. Furthermore, nutrients recovery from food supply chain waste such as food processing industry waste would be an innovative waste-based biorefinery strategy.

Therefore, the development of bioconversion process to convert the nutrients in food industry wastes (e.g. carbohydrates, proteins, lipid, and minor constituents with high market values) for the production of chemicals, materials and fuels would be the future trend for waste valorization.

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