Reducing costs by integrating ozonated water in the CIP systems

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Abstract

Cleaning and disinfection (C&D) procedures are a major concern in food and drink industries. Most water employed in food sector is consumed for C&D operations, discharging polluted waste water. This is stated at the Reference Document on Best Available Techniques in the Food Drink and Milk industries (FDM BREF) [1]. So health and environmental concerns are supporting the need for alternative sanitation technologies. Ainia has been working over the last years to develop new and more sustainable sanitation technologies. Ozone is an effective and proved sanitizing agent over a wider spectrum of micro organisms than conventional disinfectants and doesn't generate chemical residues. OZONECIP was a Demonstration Project (LIFE05 ENV/E/000251), which focused on the reduction of the environmental impact of CIP operations by using ozone. This project was focused on winery, dairy and brewery sectors. In this paper a summary of the obtained results is presented. This project showed, at pilot scale, that comparable hygienic efficiency could be achieved with ozone CIP systems, reducing the amount of water used/discharged (50%). An industrial validation of the ozone CIP system is needed to boost its wide implementation in food industry.

ECO3CIP project (2009-2013) deals with the first industrial application of ozone CIP system in dairy industry. In this paper, their main objectives and the current results are showed. This project (ECO/09/56045/SI2.564671) is co-funded by the EACI and the European Commission.

Key-words: Ozone, CIP, Food industry, BAT, sustainability

Introduction

All Food, Drink and Milk (FDM) industries, regardless of their size, geographical location or point in the production process, must comply with the required food safety standards. Processing equipment and production installations are cleaned and disinfected periodically to comply with legal hygienic requirements.

Cleaning is the total removal of organic material wastes or product components and other visible pollution. Whereas disinfection pretends to remove all pathogenic micro-organisms and the most of non pathogenic that would affect the product quality.

Some of the most important cleaning tasks are those related to the washing of process vessels, tanks and pipes where Cleaning In Place (CIP) systems are of common use. CIP are characterized by automatic cleaning programs based on a succession of several solutions of water, cleaning chemicals and disinfectants that are discharged into sewer systems together with large amounts of water necessary to rinse out residual chemicals. A CIP program can be composed of some of the following steps: (i) Pre-rinsing Soiled equipment surfaces are rinsed with water to remove the gross amounts of loose food soils; (ii) Cleaning Cycle: Removal of residual food soils from equipment surfaces. The cleaning cycle may include: 1 Caustic wash. The caustic solution is redelivered into the caustic tank controlled via a conductivity meter in the return pipe. 2 Intermediate rinses. 3 Acid wash A mild acid rinse of the equipment neutralizes any alkaline residues left and removes any mineral soil present. 4 Rinse with water; (iii) Disinfection. In a fixed ratio disinfectant is added to the fresh water. All equipment surfaces are rinsed or flooded with a sanitizing agent. Time and concentration are critical for optimum results; and (iv) Final rinsing of all surfaces with cold or hot water, depending upon the temperature of the cleaning cycle, to thoroughly remove all remaining chemical solution and food soil residues, this step is always the last in a cleaning operation.

Typically, cleaning and disinfection wastewaters contain soluble organic material, FOG, SS, nitrate, nitrite, ammonia and phosphate from product remnants and removed deposit soil, as also contains residues of cleaning agents, e.g. acid or alkali solutions the wastewater may have a high or low pH and high conductivity. The use of phosphoric and nitric acids will increase the phosphate and nitrate content of the wastewater. So health and environmental concerns are supporting the need for alternative C&D technologies.

Ozonecip (LIFE 05 ENV/E/000251) was a Demonstration Project funded by LIFE-ENVIRONMENT that was run from 1/12/05 to 1/12/08. Its objective was the reduction of the environmental impact of cleaning operations through the integration of ozone as an alternative sanitising agent instead of traditional chemicals in CIP systems. The results obtained demonstrate the environmental benefits of the ozone CIP compared to the use of traditional chemicals in CIP. Also, non-environmental factors that can affect the feasibility of the technique have been considered. Efforts focused in tank cleaning operations in winery, brewery and dairy sectors, as they are intensive users of CIP technologies. Cleaning In Place (CIP) is considered as BAT in the European reference documents, according to the project results, ozone cip is more advanced than the BATs described.

The Life funded Ozonecip project showed, at pilot plant scale, environmental advantages of the ozone based CIP system. Although data obtained at such scale is of enormous importance a validation of the system at industrial scale is needed so that wide spread implementation of the system may happen. Thus, the current project (ECO3CIP) involves the industrial scale installation of an ozone CIP system running in a section of a dairy company working under real conditions with in order to validate the system at industrial scale. In particular the current CIP system giving service to the raw milk reception area will be retrofitted to allow for the validation of the ozone based cleaning system.

Water consumption in dairies is mainly associated to cleaning operations. Also, most of the chemicals used in a dairy industry are used for the cleaning and disinfection of process machinery and pipelines. Fresh product dairies mainly use caustic and nitric acid and some disinfectants, such as hydrogen peroxide, peracetic acid and sodium hypochlorite. Disinfection agents are also used in a range of 0.01 – 0.34 kg/t processed milk. The Food and Drink and Milk Reference Document on Best Available Techniques states that waste water is the main environmental issue in the dairy sector and that the largest proportion of the waste waters is cleaning waters. The pollution load on the waste water is high due to residual milk fat and proteins as well as cleaning chemicals. The organic load caused by the cleaning chemicals is minor; the main problem is the fluctuation of the pH of the waste water, which disturbs the balance of the waste water treatment plant [1].

Within dairy industries CIP system are of common use. Thus, the development of more efficient and environmentally friendly techniques is of wide interest. The particular properties of ozone as a strong oxidant and wide spectrum antimicrobial agent lead to its consideration as an interesting choice for the cleaning & disinfection of closed equipment with potential environmental benefits in front of other sanitizers [2].

An extensive literature may be found on the use of ozone and ozonated water as a useful tool in food industries for sanitation purposes. Nevertheless, most of the work already reported on the use of ozone for sanitizing purposes within food industries focuses on its disinfecting capacity but hardly any data on its environmental benefits compared to other sanitizers is reported.

It is expected that the project becomes a reference case study in order to extrapolate the data and allow for general acceptance of the technology and widespread replication of the system.

Material and methods

The ECO3CIP project proposes to test at industrial level the ozone based clean in place system. To do so, the system will be installed in the raw milk reception area of a dairy company (Esnelat). The technical development of the system will be carried out by an ozone technology expert company (ITT-WEDECO) and the integration with the clean in place system will be performed by a CIP expert company (Instalaciones Grau). The coordination of the project and technical assistance in cleaning and disinfection and environment issues will be performed by **ainia** technological centre.

The system will be implemented in 1 of the 6 raw milk reception lines, as this is the less sensitive area of the plant to any kind of incident in the cleaning and disinfection operations. Here, current cleaning protocols are less restrictive and are less exhaustive than inside the milk plant.

For the first application project a three year schedule is proposed (the project will last from 1/6/10 to 1/6/13). The first year of the project will be devoted to preparatory work consisting on a hygienic and environmental diagnosis of the cleaning protocols performed by the dairy company in the section of the dairy factory where the implementation of the ozone CIP will be carried out. This implies the assessment of the environmental impact of the current processes by sampling of the wastewaters and instant monitoring the flow rate, pH and Conductivity of the water discharged as each cleaning cycle proceeds and analysis of the integrated sample obtained. Complementary sampling of last rinse cleaning water and swab sampling of the inner surface of the tank before and after cleaning for microbiologic and ATP analysis allows for checking the hygienic efficiency of the cycle.

Data obtained sets a picture of the reference scenario and helps to define the basis for simulation of current practice at pilot scale and test different alternatives using ozonated water and/or modifying NaOH dose. Thus, a series of tests at pilot plant scale will be run in ainia in order to obtain data to better proceed to the scaling up of the system.

The second year of the project will be devoted to design, engineering and construction of the ozone cip system integrating it into the existing conventional system.

The last year of the project will be devoted to running the system in the section where will be installed and monitoring its performance in hygienic and environmental terms in a similar way to that used for the initial diagnosis. Ozonecip and current practice will be run in parallel so a good comparison of the performance of both systems is expected.

The performance indicators to be obtained are:

a) Environmental indicators
   - Water consumed and waste water discharged per cleaning cycle
   - Organic load discharges per cleaning cycle
   - Toxicity of cleaning waste waters

b) Hygienic performance indicators
   - Microorganism count on the inner surface of the tanks
   - Microorganism count in the last rinse water
   - TOC value, , total organic carbon value in the last rinse water
   - ATP on the inner surface of the tanks after finishing completely the C&D protocols.

c) cost indicators
   - running costs per cycle
   - installation cost and payback period

Results and discussion

The environmental benefits achieved with the implementation of the proposed system is based on the adoption of a cleaner technology than current cleaning and disinfection systems employed within food processing companies. Thus, ECO_3CIP project is in line with the orientations and approaches defined in the Sixth Environment Action Programme. Particularly, it is in line with the specific objective 3 “minimising the environmental impact of economic activities” and in the part 1: “clean technologies”. The project aims to reduce the environmental impacts of the cleaning and disinfection operation in the food processing industry with a clean technology implementation approach.

Duriing developing OZONECIP project, several trials were conducted to quantify and to better know the efficiency of the use of ozonated water as a disinfectant and also as a rinse agent by comparison with the efficiency of the currently CIP protocols running at the three sectors involved in the project using water and chemical products. In each test conducted wastewater samples were taken during the complete CIP cycles by means of an automatic sampler located at de drain pipe of the prototype system and several parameter were analysed (COD, pH, conductivity, volume,…). Regarding the measurement of the hygienic efficiency, rodac plates and ATP swabs were taken from the inner surface of the tank and also samples of the last rinse water in all tests (ATP, COD, ph, microbiologic count were analysed) .

Tests consisted on polluting the inner surface of a target tank (500l) and running CIP cycles. The tank soiling procedure consists basically on the recirculation of the soiling solution into the tank followed by a dry period. To prepare the soiling solution different drinks (raw wine, beer and whole milk) were inoculated with different pull of micro organism depending on the target sector too.

From the tests carried out the alternative ozone based protocols may achieve similar levels of cleaning and disinfection efficiency of the inner surface of the tank compared to usual practice allowing for **a reduction of the water consumed by 50% and the organic load discharged with the wastewaters generated by 50%** (higher for milk related tests). Load reductions achieved are higher for brewery protocols than for winery protocols. Dairy related tests showed the highest reduction in the load present in the waste water. This is probably due to the alcoholic content in wine remnants, less in brewery and none in dairy remnants.

Therefore developing the current ECO3CIP project is expected to allow for a reduction in the water consumption and hence a reduction in the waste water volume in a dairy company. Furthermore, cleaning waste waters generated with this system show a better analytic quality while keeping hygienic efficiency.

From an environmental point of view the following achievements are expected (Table 2):

Objective	**Expected Result**	**Impact of the action**
Reduction of the water consumption and wastewater volume	25% reduction	Savings in costs for water consumption.
Reduction in the consumption of chemicals	10% reduction	Reduction of expenditure in chemicals
Reduction of the organic load in wastewater	15% reduction	Reduction in environmental taxes
Reduction in toxicity of wastewater	reduction to be determined	Reduction in environmental taxes

Table 2. Expected environmental results

- Reduction in water consumption / wastewater volume by 25%. This result should be obtained via the reduction in the volume of water needed in the final rinse as, all or at least part, of this

step should be achievable in a closed loop reducing the total time in which rinse water is actually discharged to the drains.
- Chemical consumption should be achieved in most cases by the substitution of the disinfectant employed by ozone. In the case tested under the ECO3CIP project a low value is set as objective as only a reduction in the use of NaOH in the alkaline wash is expected due to the effect produced by ozone in the first rinse should allows for such a reduction in the NaOH dose in the alkaline wash.
- A organic load reduction in wastewater by 15% is set as objective compared to current practice in the company in the target CIP

Ozone-based disinfection methods entail higher investment costs than methods based on other chemical disinfectant products as additional equipment is needed. However, the ozone based system will show lower running costs as they only consume a moderate quantity of electricity to generate the ozone. The savings on water, discharge taxes and chemical products should recuperate the higher initial outlay in most cases. But this will depend strongly on local conditions as price of water, of discharge taxes and of disinfectants substituted by ozone. A cost analysis of the system will be produced in order to evaluate the system feasibility.

Conclusions

According to all the data obtained as a consequence of the implementation of the OZONECIP project the integration of the use of ozone in CIP systems allowed a reduction of the water consumption needed to perform cleaning and disinfection operations of closed equipments in the winery, brewery and dairy sectors compared to conventional CIP protocols keeping, at least, the same disinfection and cleanliness efficiency and reducing at least by 50% the organic load in the cleaning waste waters produced.

The current ECO3CIP project (2010-2013) deals with the first industrial application of an ozone based CIP system and its validation in technical and economic terms at industrial level to boost its wide implementation in dairy industry The current results obtained at the moment, during the first year of the project shows that the best hygienic and environmental results are getting when the CIP protocols starts with a pre rinse O3 water to drain and finish with a last O3 water rinse in close loop. The industrial design of the new CIP (including ozone) for the dairy company participant has just started.

Ackkowledgements

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Project Consortium
Asociación para la Investigación en la Industria Agroalimentaria (ainia) as coordinator, ITT Water & wastewater España, SA; Instalaciones Industriales Grau, SRL; Esnelat, SL

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