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CLEANING EFFECTIVENESS AND ENVIRONMENTAL CRITERIA

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Abstract

Food production must be done under high hygienic and sanitation conditions. The most important part of it is fulfilled by cleaning and disinfection of the equipment in technological lines before and after productivity times. The CIP system is always considered with charge of soil and chemical agents going out to the environment. Food industry is known as one of the most water consuming for cleaning and disinfection, and subsequently also as a huge amount of wastewater producing. There are two factors controlling what is going out after each industrial process to the surroundings and affecting in general our environment. Namely, there are LCA and EIA.

Description of LCA factor was based on processing procedure for dairy products with different wet basis moisture content, and assessment of the level of water contamination EIA factor after cleaning and sanitation process, and when discharged to the open water sources has been taken into account. It has been compared with the new CIP system in which the chemical agents were replaced by ozone together with its facilities, and for that a type of EIA audits have been proposed.

It seems that the new CIP system may play significant role on the dairy industry for reducing the EIA factor after manufacturing dairy products. The main attention has been focused on the environmental advantages reducing water amount used in such system with ozone, and amount of wastewater discharged to the environment, and it can be proved and verified by the EIA factors.

Key words: *CIP system, ozone, environmental criteria, cleaning effectiveness*.

1. Introduction

Food production must be done under extremely high hygienic and sanitation conditions. The most important part of it is fulfilled through cleaning and disinfection applied to the equipment in the technological lines before and after productivity times. According to the BAT's suggestions CIP system belongs to the best used commonly in the food industry. The typical CIP (Clean In Place) system utilised in food engineering is always considered with certain charge of soil and chemical agents going out into the environment. That observation is very important because food industry is known as one of the most water consuming for cleaning and disinfection purposes after every unit operation in food production, and subsequently of that also as a huge amount of wastewater producing. Therefore, due to the EU Directives, particularly related to the IPPC (Integrated Prevention Pollution Control) there are two factors controlling what is going out after each industrial process to the surroundings and affecting more or less in general our environment. Namely, there are LCA (Life Cycle Assessment) and EIA (Environmental Impact Assessment). Hygienic and environmental demands that will characterise the development of new production system by two factors: LCA and EIA, include: hygienic design of buildings, new processing equipment together with cleaning and disinfection system, methods of risk evaluation and validation of risk levels, processes for inactivation and killing of microorganisms, risk related to packaging and food transportation vehicles, quality assurance systems with the FMEA methods applied.

1.1. Water

Water is the most important precondition for the preservation of life. In all food production systems and/or conversion processes with an inherent danger of environmental pollution methods to avoid adverse impacts on the ecosystem must therefore be given absolute priority. In food industry it covers area concerned with the contamination of raw materials, surface of packaging materials, and all other places being in contact with foods during processing and storage. Water used in the food industry can be classified as: general purpose water, process water, cooling water, and boiler feed water. Water supplies to the food industry may be classified as either surface or ground waters. The major impurities requiring removal are: suspended matter, microorganisms, organic matter like colour, tastes and odours, dissolved mineral matter, iron and manganese, and dissolved gases (Pascual *et al*. [4], EHEDG [5]).

1.2. Plant cleaning

Modern food processing plant is being designed to permit the cleaning operation in one ot two different ways either by: dismantling and cleaning C.O.P., or through the system known as C.I.P. shown in Figure 1. Factors influencing the degree and effectiveness of cleaning, whether by dismantling or C.I.P., include: temperature, composition and concentration of chemical agents, time and mechanical factors (Matuszek [7]).

The basic process water properties should covert all needs known from the standards methods for cleansing food plant and equipment that involves:

– **in cleaning:** using water detergent suited to soil, the hardness of the water, the material of construction of the equipment and the cleaning technique used,

– **in sterilisation:** i.e., for disinfection and sanitation, using the heat in steam or hot water as sterilisation medium, or a chemical sterilisation substances (bactericide, disinfectant, sanitizer).

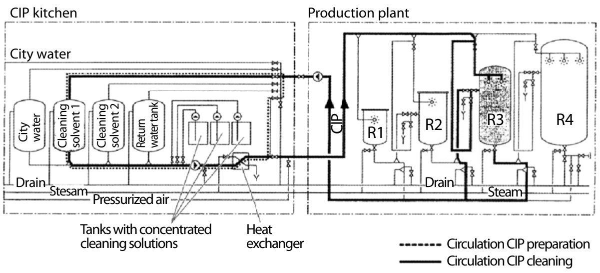

Figure 1. Example of a CIP kitchen preparing and supplying the cleaning solution to a plant (adopted after Krahe with permission [2])

2. Materials and methods

The description of LCA factor was based on the technological process procedure for two dairy food products chosen: soft cheese and hard cheese with different wet basis moisture content, and in raw milk fat content. Raw milk was contaminated with different types of microorganisms. With respect to the pollution control, the EIA factor to assess the level of water contamination after cleaning and sanitation process, and when discharged to the open water sources has been taken into account. It has also been compared with the new CIP system in which the chemical agents used so far where replaced by ozone together with its characteristic facilities (Figure2).

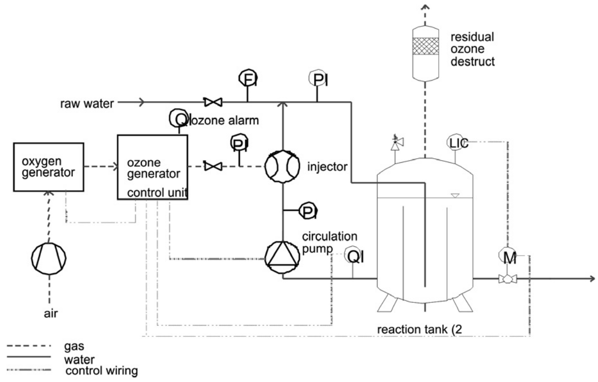

Figure 2. Ozone disinfection CIP subsystem-research stand (Life Environmental Programme [6])

When using ozone as disinfectant for kinetic organism deactivation the following equation known as Chick and Watson's law is usually taken into consideration:

where: $$\ln\left(\frac{N_t}{N_0}\right) = -K \cdot C \cdot t \quad (1)$$

N_t – amount of microorganisms after time when ozone was used,

N_0- primary amount of microorganisms in the sample,

C*t – ozone agent efficiency coefficient for organism deactivation,

C – ozone concentration in mg dm^{-3} and

t – time in minutes required for achieving required level of microorganisms deactivation.

There is also another equation known as Homa law used for the same purposes of ozone efficiency disinfection process assessment. In the Homa equation ozone concentration coefficient ‚C' is with power ‚n' and time ‚t' with power ‚m' value. The both power value are taken out from the experiments for every separate final or semi-final product case, which include precise data about raw material content with respect to the fat, protein, and other components influencing EIA factor after cleaning and disinfection processes.

3. Results and discussion

The Chick and Watson's equation was applied for the ozone assumed microorganisms deactivation selected from the dairy industry and presented in Table 1 with the relevant products value (Matuszek [7]).

Table 1. Ozone agent efficiency coefficient for deactivation appled to certain groups microorganisms

Microorganism	C*t
Pseudomonas	0,01
Acinetobacter/Moraxella	0,1
Flavobacterium	0,1
Micrococcus	0,1
Streptococcus	0,02
Corynebacterium	0,1
Lactobacillus	0,1
Coliforms (for example *E. coli*)	0,02

Cleaning effectiveness regarding chosen products with the relevant LCA and EIA factors for environments for the above microorganisms taken as example, that can exist at any in the dairy equipment can be estimated as presented below.

In comparison the product value of the C*t (mg*min*dm^{-3}) as the ozone agent efficiency coefficient for organism deactivation, for example to achieve 99% level of deactivation *E. coli,* for pH 6-7, in the temperature 5 ^{0}C, the value of that product for ozon is equal 0,02, when for chlorine that product value is enclosed in the range of 0,034 – 0,05, and for chlorine dioxide that product value is located between the range of 0,4 – 0,75.

4. Conclusions

- Using the CIP technique with ozone CIP disinfection subsystem the following can be achieved: a significant reduction of water consumption for cleaning and disinfection, an improvement of wastewater quality through the reduction of its organic pollution, the absence of unhealthy chlorine derivatives like THMs, chloramines and chlorophenols in the wastewater after the sanitising operations, energy savings because ozone is used at lower temperatures, reducing odour emissions, and facilitating the wastewater treatment due to an extra oxygen concentration coming after ozone action.
- Effectiveness of using ozone can also be described more precisely in the future when the model of microbial grows together with the mechanism of bacteria adhesive forces mainly at the food contact surfaces will be better known (Lindhorst [8], EU funded Project [10]).
- Required value ozone cleaning effectiveness product for selected microorganisms should be calculated after the food contact surfaces cleanliness characterisation by contact angles wettability measurements and by calculation of the interfacial tension and two major adhesion i.e., van-der-Waals and electrostatic forces (Marmur et al. [1], Bobe et al. [3], Matzelle and Reichelt [9]).
- It may seem that the CIP with ozone subsystem can play significant role on the dairy industry for strongly reducing the EIA factor after manufacturing dairy food products.
- It is suggested that the EIA factor can also be used as environmental performance evaluation tool for industrial improvement as well as for environmental strategy, to support decision making in compliance with ISO 14001 and EMAS.

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