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Enhancing the governance of industrial wastewater using cleaner production and water footprint principles: A case study of two dairy companies in Palestine

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ABSTRACT

Sustainable wastewater management in the agrifood industries relies on pollution control at the source by maintaining Cleaner Production (CP) approaches, and minimizing the Water Footprint (WFP). The challenges for applying CP and WFP call for having effective governance, which will help solidify the networking and enhance communications between all parties. The determined WFP for the Ultra-Heat Temperature (UHT) milk for case study A is 0.239 m^3. Case study (A): produces about 20.5 m^3/d of UHT milk, which is 3% of the daily dairy needed in Palestine. It consumes about 8.915 m^3/d of water, while the consumption of UHT milk in Palestine reaches 550 m^3 UHT milk/d, considering case study (A) produces UHT only. This means consuming about 297.158 m^3/d (about 108,468 m^3/y), assuming that case study (A) applied 5–6 CP approaches and reduced water consumption by 230,000 m^3/y. The SWOT analysis used to analyze CP and WFP applications in the dairy industries in Palestine revealed that the best practice to achieve that is by-law enforcement. The willingness of the industrial sector to apply the CP and WFP forms a core governance element to enhance industrial wastewater management in Palestine.

Keywords: Water governance; Industrial wastewater; Wastewater management; Dairy industry; Cleaner production; Water footprint

1. Introduction

Globally, most of the water use occurs in the agricultural production, but there are also substantial water volumes consumed and polluted in the industrial and domestic sectors [1]. In Palestine, approximately 62% of the water is consumed by the agricultural sector [2]. Availability and free access to water resources are crucial for sustainable development in Palestine; however, the Israeli occupation opposed any development of the water sector, and all the signed agreements with the Israeli side tied up the Palestinians [2]. Due to water scarcity, moving toward non-conventional water resources (desalination and water recycling) became more convenient, where desalination in Israel increased production from 227 MCM in 2010 to 600 MCM/y covering about 42% of the drinking water needs in Israel [3].

Building the new water and sanitation infrastructure create new challenges on the Palestinian communities in all aspects of life. However, the main challenge is how to achieve efficient management and governance in the Palestinian water sector. Therefore, many legal, administrative and institutional reforms were endorsed within the Palestinian new Water Law aiming at enhancing the effectiveness of water governance including private sector involvement [4–6].

Food industry is considered as one of the biggest investment sectors in Palestine. With a total investment of 70 million USD/y. West Bank market needs about 500–550 ton/d, about 72% of the need is covered by local factories

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production or homemade production are of percentage 62.5% and 37.5%, respectively. Moreover, Palestinians spend about 36% of their income for food, with a monthly dairy consumption of 4 kg/capita, and a direct employment of 2000 employees in dairy industries [7].

The number of registered dairies in the Ministry of National Economy (MNE) is 41, with great variation in production capacity and technology, and geographically distributed all over the country and this is reflected in the governance [7], none of the dairy industries have the ISO certification 14000 of the International Organization for Standardization (ISO) [8].

Although, the treatment of industrial wastewater using a combination of physical, chemical, and biological processes may produce recycled water complying with local national standards, the annual capital and operational costs of such technologies are very high [9,10]. Consequently, Cleaner Production (CP), which follows pollution prevention approaches, offers industrial wastewater governance in the agrifood industries a significant mix of both economic and environmental benefits [11,12]. For industrial wastewater treatment, Membrane Bioreactors (MBRs) tolerate high organic loading rates and produce recycled water of high-quality with less space requirements and less sludge production, and treated wastewater can be reused for certain purposes [13].

This research aims to identify approaches to implement CP and WFP principles to achieve effective governance for wastewater management in the agrifood industries by taking two Palestinian diary companies as case studies. In addition, the impact of implementing effective regulations on the management of industrial wastewater from dairies in the West Bank was analyzed in depth, considering the perspectives of stakeholders.

This paper has the following specific objectives:

- To assess the status of applying the CP and minimizing WFP in Palestine.
- To identify the challenges for enforcing and implementing of CP and WFP to achieve sustainable management of industrial wastewater from two Palestinian dairy companies.
- To identify the opportunities for developing CP and WFP in the targeted dairy industries considering political, sociocultural, and financial factors.

2. Methodology

The current study represents an essential part of the INWA project "Promotion of Applied Integrated Practices and Technologies for Sustainable Industrial Wastewater (INWA) Management in Palestine". Within the Palestinian-Dutch Cooperation Program on Water (PADUCO2), the INWA project was carried out at Birzeit University, Palestine, from 2018 to 2021.

According to Hufty [14], governance refers to the "interaction and decision-making among the actors involved in a collective problem that lead to the creation, reinforcement, or reproduction of social norms and institutions". These actors can be located at different levels, with different priorities and power, and can influence both formal (legal) and informal (social practices) institutions. Here, institutions refer to the 'rules-of-the-game', and not as a synonym for organizations, which fall into the actors' category. The applied Governance Analysis Framework (GAF) approach [14] included a descriptive examination of the perceptions and experiences of different key-actors related to the CP and WFP. The study scope and methodology are limited to the targeted industry through interviews and analysis of CP and WFP to analyze potential governance gaps that contribute to effective wastewater management in targeted dairy industries.

For data collection in relation of the objectives mentioned above, the study opted for a mixed approach of qualitative and quantitative methods using technical questionnaires, workshops, focus groups, documents review and personal interviews [15].

3. Results and discussion

In order to examine the applications of CP and WFP tools by the Palestinian dairy industries, five large industries covering more than 90% of the market share were targeted. Due to confidentiality and absence of environmental management, few data were collected. A list of remarkable observations was reported about the dairy industries, which apply CP and WFP tools [15]. The geographical location of companies under study affected their water consumption, where those located in the northern of The West Bank, consumed water much more than those in the southern area. Dairy companies shared almost the same production processes using diverse technologies and produced the same dairy products. Out of five companies, only one performed pretreatment of wastewater before discharge to the public network. Companies' administration has little knowledge about local laws and regulations related to industrial wastewater management, unfamiliar with CP and WFP terms. Good housekeeping and water recycling were not noticed at small-size companies; however, the willingness to apply CP and WFP principles at large companies was more compared to smaller dairy firms [15].

3.1. Actors playing role in wastewater management

To determine the main actors interacting and affecting the wastewater management, GAF was applied [14]. The actors were divided into 4 main sectors: governmental, private sector, civil sector and foreign entities. All those actors were examined by answering the questionnaire prepared for the governance analysis exercise, supported by PADUCO's second round of integrated research projects[1] [15]. Classifying the actors in terms of their influence on managing the industrial wastewater was found to depend on the actor's sector. Considering the actors categories, Fig. 1 shows that, the highest number of responses was made by the governmental sector, reflecting the highest management influence. Other actors who particularly deal with the

[1]This document forms a core part of the project "Promotion of Applied Integrated Practices and Technologies for Sustainable Industrial Wastewater Management in Palestine"

credit of having the highest influence are, simply because they used the power and influence [15].

The best actor's management strategy was to concentrate on important and avoid the less important environmental challenges to save energy and time. Fig. 2 depicts the actor's role considering their influence (power) and interest towards industrial wastewater management.

3.2. Current management of Palestinian industrial wastewater

All the actors from the previous section were asked to answer to the best of their knowledge about the industrial wastewater management. One answer was dominant: no proper management or there is no management at all. Actors reported the following main challenges facing the management of industrial wastewater:

- Lack of capital expenditures to install pre-treatment units for industrial wastewater before connection to public sewerage networks. Pre-treatment units will protect the wastewater treatment facilities and reduce environmental and public health hazards.
- Current regulations regarding industrial wastewater lack clear mechanisms for enforcement, which encourages non-compliance of industrial firms with local rules, especially those established in the area C (rural areas with no Palestinian civil administration).
- Current urban Wastewater Treatment Plants (WWTPs) are designed not to receive raw industrial wastewater. Compliance with obligatory pre-treatment regulation of industrial wastewater is mandatory by the Palestinian Standards Institute (PSI).
- High capital and operational costs for industrial

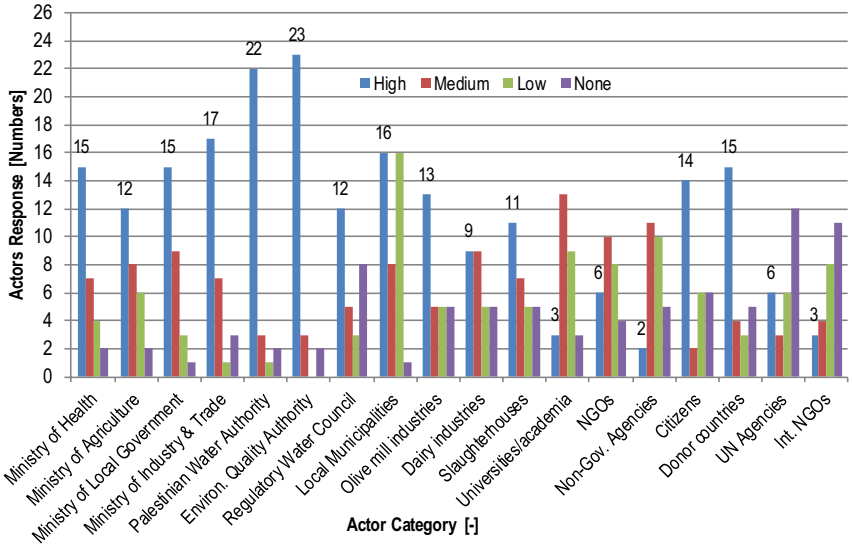

Fig. 1. Actor influence and interest on industrial wastewater management.

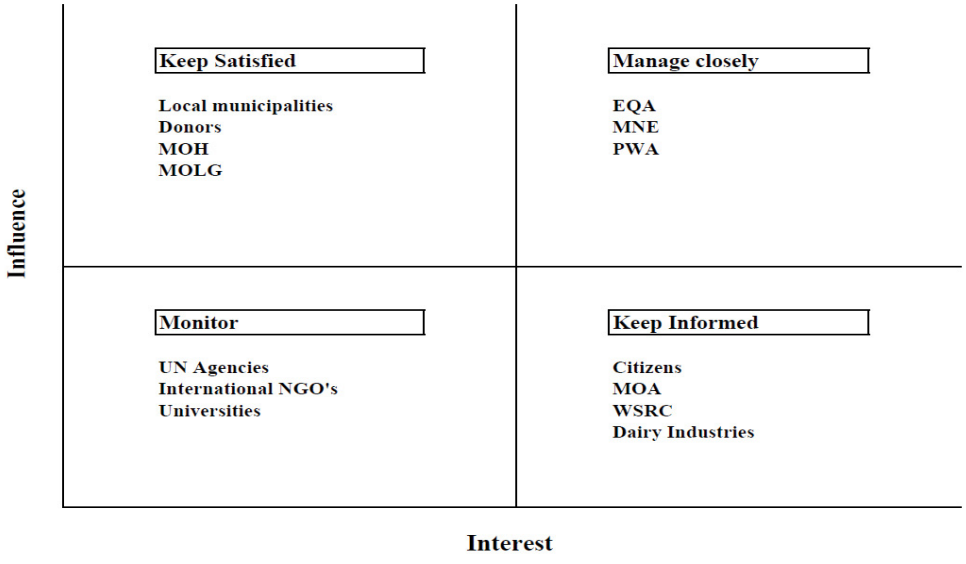

Fig. 2. Actors influence on industrial wastewater management in Palestine [15].

wastewater treatment are due to scattered distribution of industries, lack of industrial zones or centralized treatment facilities. In addition, most of industries are small "family business" with poor financial resources.
- Green and sustainable industrial sector call for public health protection and environmental pollution prevention, but associated with capital investment aiming at saving fresh water resources by reusing, and moving towards sustainability and green economy.

3.3. Legal framework

The legislative framework for the Palestinian water sector is divided into four main levels and each level is governed by different entities. The main Palestinian laws related to industrial wastewater are:

- Public Health Law No. 20 of 2004.
- Law No. 7 of 1999 on the environment.
- Decree Law No. 14 of 2014 on water.
- Decree Law No. 10 of 2011 on Industry.
- Local Authorities Law No. 1 of 1997.
- Presidential Decree No. 22 of 2003 on the Competence of Governors.
- By-law governing house and facilities connection to the public sewerage network 2013.

3.3.1. Guide on by-law implementation governing house and facilities connection to public sewerage network

Issued by the Council of Ministers in July 2018, the guide entails the by-law on connection of households, commercial, industrial and agricultural facilities to the public sewerage network. Apart from collection of all Palestinian water legislations, the guide illustrates the roles and responsibilities of various government agencies responsible for licensing, control and establishment approval of industrial, commercial and agricultural facilities. The by-law faced difficulties and obstacles in implementing its provisions by the water service providers. Main obstacles behind inefficient enforcement of the by-law included absence of representatives of key national ministry like Ministry of Local Governement (MoLG), and Ministry of Agriculture (MoA) and PSI. Other subject related ministries (Health and EQA) played only minor roles in licensing and approvals committees.

3.3.2. Dairy industries establishment and effects on wastewater management

Following up the life cycle for establishing the dairy industries in Palestine, and to initiate a coordination and cooperation between the stakeholders in the water sector, water projects are closely watched [7] by the Ministry of National Economy (entity responsible for managing the establishment, registration, licensing of all industrial and commercial facilities including the dairy industries in Palestine) [8]. There are many industrial licenses obtained from the Palestinian Ministry of National Economy (MNE). Fig. 3 and 4 illustrate the main types of licenses, which are industrial establishment license (Fig. 3) and to operate an industrial facility (Fig. 4).

3.4. Core governance issues of dairy industries in Palestine

The dairy industries in Palestine pertaining to key water governance share the same aspects with other Palestinian industries. Core governing elements for a sustainable industrial sector in Palestine include water supply, wastewater services, energy supply, donor countries impacts and the social and public participation [16]. A brief description of the current governing elements is as follows:

- Water Supply for Industrial Sector in Palestine

There are many regional institutions supplying water in Palestine, including municipal water departments, independent utilities, water supply and sewerage authorities, and local committees and village councils. According to Nazer et al., [17] each institution has its own administration and regulations with drastic variation on their capabilities and authorities.

- Wastewater Services for Industrial Sector in Palestine

In 2005, only 104 localities in Palestine were connected to wastewater networks out of 557 localities [18]. For an example, Birzeit city having a total population of 6000 capita, in addition to, around 16 thousand people coming in daily bases or living in the city who have one of the biggest universities in Palestine is being without wastewater network till today.

The connected localities to sewerage network are one of the following types:

- Connected to sewerage network without WWTF

Dairy companies discharge industrial liquid waste streams to public sewerage networks illegally, and also into the nearby seasonal streams/Wadis.

- Connected to sewer network with WWTF

The production size of the dairy company governs the pre-treatment requirements. Here, two types of connection scenarios exist as follows:

- ***Scenario 1***: Pre-treatment is mandatory for one dairy company in an eastern side of Nablus city. The Environmental Control Unit (ECU) of Nablus municipality controls the treated effluents to prevent any harm to sewerage network and the environment.
- ***Scenario 2***: Allow connection without pre-treatment: This is the scenario for Al-Bireh WWTP; where, one Dairy company is connected to the public sewerage network due to small size of production line.

3.4.1. Energy supply for the Palestinian industries

Based on the Palestinian council of ministries decree dated on Sep 15, 2015, the fourth clause point number 3: "the government will use 50% of discount on the purchasing prices; which equals to 0.0052 NIS for each electrical unit, in renewable energy projects of schools and hospitals

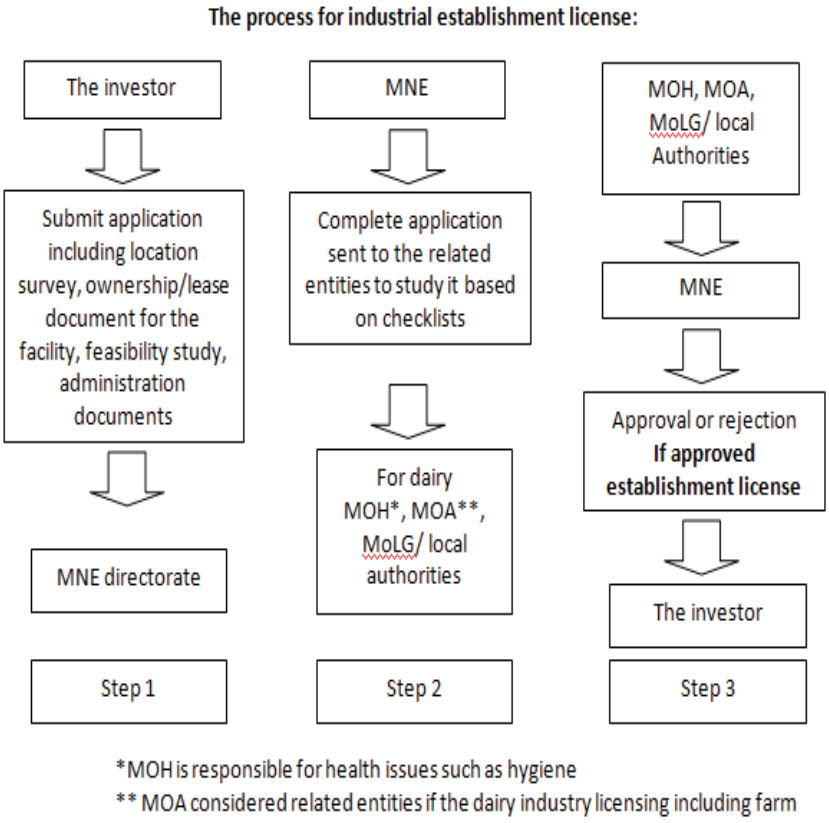

Fig. 3. The process for industrial establishment license.

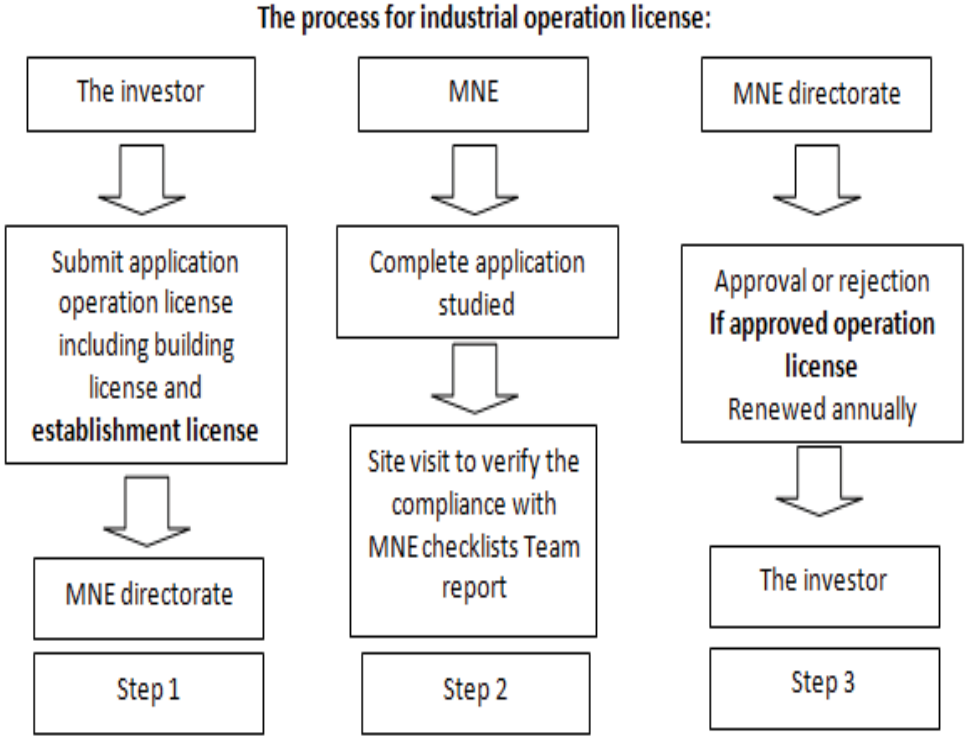

Fig. 4. The process for industrial operation license.

in coordination with MOE and MoH" where, the industrial sector was not included [15]. The Palestinian government failed to fulfil its commitment towards the industries using renewable sources. As per the first decree of the year 2018 for regulating the renewable energy projects, the government forced the electrical distribution companies to buy the electricity generated from renewable sources according the specified prices. In return, the government should compensate the differences between the two prices; the original price (usually the price from Israeli supplier) and the price from renewable sources [15].

3.4.2. Donation management for water sector in Palestine

The Palestinian National Authority (PNA) has been formed under the Declaration of Principles in Oslo by the Israeli side and (PLO) in 1993, and based on the Protocol on Economic Relations, also called as the Paris Protocol, signed on 29 April 1994. The PNA finance is from tax revenues collected on its behalf of Israel in accordance and donor assistance.

Donation for the Palestinian (The donor's contribution in the Palestinian budget) is very remarkable. Financing of water sector in Palestine (PWA) also receives donors' contribution[2]. The government budget for the PWA barely covers the salaries and administration expenditures, while almost all water development projects in Palestine rely on international funding. To get the donor funding, a three – year plan is developed periodically by the Palestinian to outlines the sector's developmental needs. This plan is submitted to different donors including the EU, USAID.

If the proposed project or part of it is to be implemented in the Area C, donors request approval from the Joint Water Committee (JWC) and Palestinian National Authority (PNA) donors postpone or cancel or relocate the fund, if it is rejected from JWC and PNA. The donation amount for water and sanitation sector from 1994–1998 is around 315 million USD for 112 projects[3].

3.4.3. Social and public participating on management for water sector in Palestine

Palestinian people are burdened heavily in all the life aspects, with limited financial resources and high cost of living. It is normal that, people will consider the environmental issues at the bottom of their daily priorities.

Palestinian people is highly educated, and have the knowledge; but, the dominated attitude is "not in my backyard" or "out of sight, out of mind" mentality. An example is, Zahrit Al- Finjan Landfill (LF), near Arraba town in Jenin governorate, Northern of the West Bank. This LF, serving Al-Bireh/Ramallah govenrorate as well, forms an environmental disaster to the people living in Arraba town nearby the landfill with suffering and complaints. On the other side, people in Ramallah don't pay attention to the suffering of Arraba`s people.

The public participation for environmental impact assessment projects depends on the entity running the project, weather it is governmental and non-governmental entity, thus performing EIA is mandatory for both entities; but the public participation in the non-governmental is more than the governmental entity.

Small-size industries and family owned industrial enterprises are hesitant to opt for CP and WFP approaches, even a "luxury research" effort for some specialists. Increased coverage of water and sanitation services in the industrial zones and rural communities is considered as a priority.

3.5. Palestinian dairy industries as case studies for CP and WFP applications

The study targeted two Palestinian diary companies with focus on one production line from their dairy products.

3.5.1. Selection of case studies

This research targeted the application of cleaner production and water footprint principles in two Palestinian diary companies, as case studies to enhance the governance of industrial wastewater management. The selection of case studies was subjected to data availability in addition to regional characteristics, considering the governing, technical and financial aspects to enrich the research (Table 1). Due to privacy reasons, instead of real names, the dairy companies were refered to as case study A and B. During the study, case study B was closed for rehabilitation purposes.

3.5.2. Production line selection

UHT milk is selected for this study for the following reasons:

- In both case studies, UHT have the largest portion of total dairy production. For case study A, UHT production equals to 7488 m^3/y out of 35,942 m^3/y for the dairy industry which is equal to 20% of its dairy production. For case study B, UHT production equals to 789 m^3/y out of 2,273 m^3/y for the dairy industry which is equal to 35% of its dairy production.
- Based on the literatures, milk processing has medium water usage and waste water management indicators, since the production amount are bigger than the wastewater.

3.5.3. Production technology

Case study A: using various technologies such as Tetra Pak, Ever green, Arika, those technologies are from different originalities as per the feedback from the quality control engineer of the same production line might have more than one technology.

The cleaning process needs to be optimized to fit all the production lines.

Case study B: using unique technology which is Tetra Pack, the cleaning process follows the manual of the manufacturer.

3.5.4. Cleaning technology

Case study A: using Clean in Place (CIP) by computerized system and Clean Out Place (COP) in which some parts out of the system named decipher cleans it separately.

[2]https://water.fanack.com/ar/palestine/water-management/financing-of-the-water-sector/

[3]Donor investment in Palestinian development 1994–1998

The industry refused to give any data related to cleaning materials.

Case study B: using CIP only; and the material revealed as per the photos here after "hydroxide (NaOH) and phosphoric acid (H_3PO_4)".

3.5.5. Wastewater management

Case study A: frequent lab testing of the industrial wastewater discharged. While Case study B has different results for testing from various labs [19].

3.5.6. Applying the cleaner production (CP) approaches

Case study A applied the following Cleaner Production (CP) approaches [20]. Table 2 summarizes the key CP measures opted for in the production lines of the dairy company.

- Good House Keeping (GHK) measures

Thirteen GHK measures were implemented, including the preventive maintenance, cleaning, insulation of pipes or water feed tanks, switching off equipment not in use, or lowering pressure settings in the compressed air system. These measures could bring annual savings of more than 10,000 Euros and a reduction of 95 tons of CO_2 emissions.

- Replacing a boiler burner for pasteurization

The company replaced a diesel burner for preparation of hot water for pasteurization with a more efficient

Table 1
The selecting aspects for the two case studies

	Aspect	Case study A	Case study B
Governing	Water supplier	Municipal water department	Municipal water department
		Daily water consumption	Water consumption: 60 m^3/d
	Wastewater disposal	Public network with no WWTP	Public network with no WWTP
	Energy supplier	Hebron Municipality	NDECO
	Raw materials	Local suppliers owning cow farm	Local suppliers
Technical	Technology used	German technology	For UHT Tetra Pack
		For UHT ever green technology	
	Certificates	Palestinian Standard and Measurement (PSM)	Palestinian Standard and Measurement (PSM)
		9001 ISO	9001 ISO
		Working on ISO 22000	Working on ISO 22000
Financial	Investment	Large capital investment	Small capital invetment
		Production capacity 120–130 thousand[1] liter of milk per day	Production capacity was 22–25 thousand liter of milk per day
	Market share	30% of local market	5%–10% of local market
	Targeted market	Local and regional markets	Only the local market

*NEDCO: Northern Electricity Distribution Company
[1]Calculated for 300 working day in the year

Table 2
The saving opportunities for case study A is as follows [20]

	Saving opportunities[1]					
Action	Economic key figures			Resource savings & environmental impacts per year		
	Investment euros	Savings euros/y	PBP years	Water and raw materials	Energy MWh	Pollution reduction
Good housekeeping (GHK)	5,000	10,190	0.5	–	127	962 t of CO_2
Energy efficient lighting	3,000	3,840	0.8	–	30	
Replacing burner in boiler for pasteurization	50,000	21,000	2.4	–	170	218,000 m^2 of wastewater
Chiller	227,500	125,370	1.8	–	962	
Recovery of CIP water	160,000	218,000	0.7	230,000 m^3 of water	–	
Total	445,500	378,400	1.2	230,000 m^3 of water	1,289 MWh	

[1]Numbers based on production value from 2015

dual burner using diesel and LPG. Total savings could be 21,000 euros/y, and CO_2 emissions could be reduced by 127 t/y.

- Energy efficient lighting and chillers replacement

Introduction of new and more efficient lighting will bring a 30% reduction in energy used for lighting, saving 21 tons of CO_2 emissions per year. Also, replacing the chiller with new high energy efficient systems has replaced the old model (increasing COP from 2 to 4) (Table 2).

This modernization will reduce the energy consumption by 25% and will bring significant savings to amortize the initial investment within 2.5 years. CO_2 emissions will be reduced to 720 t/y.

- Recovery of CIP water

Water used in CIP rinsing can be recovered and reused for pre-rinsing. This measure will yield a significant reduction of atleast 230,000 m^3/y by comparing the existing water use.

3.5.7. Effect of using water footprint (WFP)

The following data were received from the case study A. The control manager [20] collected the data, where the inventory analysis is done using the Eco-Invent Database, which is part of the SimaPro software. The overall balance of the WFP for the production of 1 L UHT milk in paperboard box produced by case study A was 239 L.

In a comprehensive water footprint study [20], key category indicators were taken into consideration including the water scarcity (availability), eutrophication, aquatic toxicity (ecotoxicity) and acidification (as a midpoint indicators). Table 3 presents the main inputs and outputs for the WFP impact categories for the production of UHT milk [20].

The result found for the water footprint of UHT milk is: 239 L of water used to produce 1 L of UHT milk. Most of the water footprint in this case study was mainly used as cow feed (70%). As Palestine lies in a semi-arid region with limited annual rainfall, this water footprint forms a sustainability issue.

4. SWOT analysis for using CP and WFP in dairy industries

To enhance the current industrial wastewater governance using the CP and WFP tools, analyzing the existing situation is needed according the facts of supplying water, wastewater management, energy supply, funding and donation for water sector. For this purpose, analysis of strengths, weakness, opportunities, and threats (SWOT) for using the CP and WFP principles in dairy industries was performed. Despite multiplicity of influencing actors and institutions that interact in many management levels, Hasan [20] considered SWOT analysis as a strong tool in formulating the strategic alternatives for wastewater governance and management.

4.1. Strengths for using CP and WFP in dairy industry

Table 4 lists only the main 5 out of identified 10 Strengths (S).

A brief description is as follows:

- ***S1:*** Palestine faces water scarcity challenges. Green economy and sustainability requires a search for alternative water sources including water recycling, and resources recovery and CP.
- ***S2:*** The multiplicity of influencing actors in using CP and WFP as the tools for wastewater governance, enriches the process, make it more updated, and increasing the chance for covering all the aspects of governance; actors with different perspectives; but unified under one aim, and working integrally to meet it. This point could be considered as a weakness too, which is illustrated in the weakness section.
- ***S3:*** Pre-treatment of industrial wastewater in decentralized onsite systems requires huge capital investment. As per valid regulations, the dairy industry cannot connect to public sewerage system without pre-treatment

Table 3
Inputs and outputs per WFP impact categories of selected production line [20]

Functional Unit (UHT Milk)	1	L			
			Water footprint impact categories		
Inputs and outputs		Water scarcity (availability)	Acidification (acidity)	Eutrophication (phosphate + nit)	Aquatic toxicity
Inputs					
Water, m^3		0.239			
Outputs					
Phosphate to water, kg				0.0057	
Phosphate to water, kg				0.0002	
CO_2 (carbon dioxide), kg			2.878		
SO_2 (sulphur dioxide), kg			0.006		
NO_x (nitrogen oxides), kg			0.014		
Comparative toxic units CTUe					0.0818

Table 4
Analysis of SWOT matrix for using CP and WFP in the Palestinian dairy industries

	Strengths (S)	Weaknesses (W)
Internal Factors and External Factors	S1 Water scarcity S2 Diversity of influencing factors for using CP and WFP S3 The establishment of WWTP all over Palestine S4 New guidelines for sewerage connection S5 The green fashion invades Palestinian market	W1 Insufficient and inefficient sanitation services W2 High cost for some techniques of CP and WFP W3 Inefficient and institutiona fragmentation of wastewater sector W4 Lack of treated wastewater reuse W5 Lack of awareness and community participation

Opportunities (O)	Strengths and Opportunities (SO)	Weaknesses and Opportunities (WO)
O1 Donors willingness to support projects related to sustainability O2 Ensure cost recovery via solid pricing systems O3 Availability of technical experience O5 Technical barriers for export	1. Using S1, S 4 to benefit from O1, O2, O4 to introduce new technologies for water saving. 2. Establish regulations using S3 to support point 1 and to improve the pricing system O3.	1. Using O1, O2, O4 to overcome W1, W2 by emerging new technologies. 2. Using O3 to alleviate W4 by introducing a new pricing system. 3. Using O5 to overcome W5.
Threats (T)	**Strengths and Threats (ST)**	**Weaknesses and Threats (WT)**
T1 Israel takes control over importing T2 Pollution of the water resources T3 The population growth T4 keep attitude not enforcing the laws	1. Using S2 to overcome T1 and T2 by making use NWC to help in the negotiations with regard to the water issues. 2. S3 can be used to overcome T3 by applying and enforcing the laws regarding pollution.	1. The threats T1, T2 regarding Israeli control over water can only be overcome through negotiations and pushing the world community to support this issue.

as per the parameters for connection. Using CP and WFP principles will reduce pollution loads and allow for connection directly without installing pre-treatment systems.

- ***S4****:* Few local NGOs conducted projects promoting sustainability, optimizing resources use, and minimizing the CO_2 emissions. The NGOs used environmental tools such as CP and WFP in SwitchMed[4] program and MENASTAR[5] projects, which are good examples for applying the CP and WFP approaches in by Palestinian NGOs.
- ***S5****:* Palestinian dairy industries has started few initiatives to optimize resources use as a global trend, and started believing of the financial benefits. Some dairy factories tried to compete at local and regional markets to acquire global certifications. The first Dairy Factory in Gaza strip acquired in 2019 the ISO 22000 certification [21].

4.2. Weakness for using CP and WFP in dairy industry

- ***W1****:* Wastewater services are insufficient and inefficient with only 104 localities out of 557 localities in Palestine are connected to public sewerage networks [18]. Rural communities with industrial firms lack the financial sources to establish municipal sewage works. Therefore, family owned firms discharge effluents without prior pre-treatment, where CP application is not a priority.
- ***W2****:* High cost for some techniques of CP and calculating the WFP for industries in Palestine seems to be luxury, relating to the current status from lack of wastewater services and severe water scarcity.
- ***W3****:* Determining the key actors related to wastewater governance is sometimes insufficient, where ignorance of integrating inputs during the legislation phases, or enforcement.
- ***W4****:* The institutional status of the wastewater sector in general is highly fragmented and inefficient, despite the fact that laws are present, but poor enforcement.
- ***W5****:* Communities lack participation in wastewater management. This exerted financial costs on the Hebron municipality through the rejection of a centralized municipal WWTP project.

4.3. Opportunities for using CP and WFP in dairy industry

- ***O1****:* Donors' willingness to support projects related to sustainability is an opportunity for Palestinians to implement pilot projects which focused on wastewater with water reuse schemes.
- ***O2****:* Enforcing a financial system forms an opportunity to advance the cost recovery and promotes a financially sustainable sanitation sector in Palestine.
- ***O3****:* Availability of technical expertise and experience by local academia through which Palestinian universities are open to a new specialization in green growth and renewable energy.
- ***O4****:* The social media marketing has the power nowadays, taking the advantage to promote eco brands using CP and WFP principles, or calls for optimizing the consumption of resources.
- ***O5***: The technical barriers for regional export encourage the dairy industries obtain the international certification to comply with the required technical aspects of international exports.

4.4. Threats caused by external environmental conditions

- ***T1****:* Israel's full control over the imports, including prohibition of materials imports, claiming the double usage. Despite that, some of those materials are crucial for the CP promotion and contribute very well in reducing the WFP.
- ***T2****:* Disposal of untreated industrial wastewater forms a direct threat to water resources.
- ***T3****:* Increased population growth exerts pressure on the scarce water resources.
- ***T4***: Hesitance and lack of political base well behind the poor enforcement of municipal laws.

5. Conclusions and Outlook

This study aimed at identifying the approaches to implement a Cleaner Production (CP) and Water Footprint (WFP) principles to achieve effective governance for a wastewater management in the agrifood industries by taking two Palestinian diary companies as case studies. Considering the perspectives of stakeholders, the challenges facing effective enforcement of local regulations on industrial wastewater management in the West Bank was analyzed in depth. The study concludes the following:

- The municipal by-laws on connection of industrial facilities to the public sewerage networks must be a reference guide for the relevant authorities for monitoring and inspection of industrial discharges. Establishing an inter-ministerial committee to follow up the implementation of the by-laws and update the regulations could ensure sustainable management of industrial wastewater in Palestine.
- Developing a unified licensing system and coordination between the relevant authorities could facilitate merging some licenses, thus reducing conflicts. Raising environmental awareness of the owners of industries, initiate channels for communication, guidance and technical support could reduce environmental pollution and advance cleaner production.
- Benefiting from the Memorandum of Understanding (MoU) signed between the Palestinian Police and the Environmental Quality Authority (EQA) to establish environmental officers with duties to follow-ups

[4] SWITCHMED, an initiative to support and connect stakeholders, aimed to scale-up the social and eco innovations in the Mediterranean region. https://www.switchmed.eu/en/about-us.

[5] The project aimed to strengthen the institutional infrastructure and support business and industry in the Middle East and North Africa (MENASTAR), and targeted 10 countries. It covered a series of activities to strengthen institutions developing and using standards, and to increase the capacity of business and industry to apply key standards within the context of sustainable development. The project was funded by the Swedish International Development Cooperation Agency (SIDA) and implemented by ISO. https://www.iso.org/sites/menastar/.

and control of illicit connections and/or discharges of industrial wastewater.
- How "SimaPro", an environmental software program, could be adapted to medium-size small industrial enterprises and how the environmental and socio-cultural side could endorse industries to invest in pollution prevention, and CP. Initiating communication channels between the local universities and factory owners could help in this regard.

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