Full Sanitization of Buildings with Industry 4.0 Management and Economic Advantages

ROBERTO MOSCA, MARCO MOSCA*, FEDERICO BRIATORE
Industrial and Transport Engineer Department (D.I.M.E.),
University of Genoa,
Via all'Opera Pia, 16145, Genoa (GE),
ITALY

FABIO CURRÒ
TCore S.r.l.,
Via San Siro, 27, 20149, Milano (MI),
ITALY

*Corresponding Author

Abstract: - The Authors, in this article, present a case study reporting the management and economic comparison between the traditional methods used for sanitizing confined spaces and an innovative process, performed by trained Operators using a 4.0 machine, created by the same Authors, able to produce and dismiss dry Ozone (thus replicating the Chapman Cycle which happens in the Ozonosphere) and to emit UVC-rays in different wave lengths, so providing distinct functions for surface or surface-fabrics sanitization. The machine represents a significant step forward compared to the current sanitation methods, providing guarantees of absolute sanitization of the treated rooms at decidedly favorable costs. Contrary to traditional methods it is to be noted also the full compatibility with critical environments containing elements like paper or electronics. It makes it possible, as always necessary but even more so in a Pandemic period, to carry out this operation daily, rather than bimonthly as is currently the case in most residences for the elderly. The case study presented compares, on a typical structure, the economic sustainability of such incremental, use of the new technology.

Key-Words: - UV-C Rays, Gaseous Ozone, Sanitization, Economic Sustainability, COVID-19, Industry 4.0

Received: March 22, 2023. Revised: August 29, 2023. Accepted: September 12, 2023. Published: September 22, 2023.

1 Introduction

This case study is intended also as proof of the validity of what was described in a previous article, [1]. The structure is a Nursing Home that hosts an average of 100 people. Figure 1 shows a typical floor that has a net size of 516mq and a height of 3.5m. The floors of the structure are four, for a total of 2,064 sqm useful. Sanitation is currently entrusted to external companies. The cost paid is 1€/m2 per treatment (this number varies depending on the Supplier, area, and structure from 1 to 4€/m2), with an outlay of 2,064€ per intervention. The number of monthly interventions is historically set at two, for reasons of economic availability, with a total outlay of 4,128€/month. It should be noted that this number of interventions is largely insufficient to protect the patients and the personnel from bacterial or viral infections (including Covid), to counteract which it is necessary, according to the medical staff interviews performed, a minimum number of 10 treatments/month, to be extended, ideally, to one per day; it should be noted that the Supervisory Authorities on this type of institutes, following COVID-19, have indicated this value as indispensable to avoid structure closure. Starting from this premise, at the request of the Management of the structure, a study was conducted to make an economic comparison with the sanitization currently performed by external companies using chemical products. After a careful analysis of the facility, it was decided that, for optimal performance of the process of sanitization, it would be necessary to use two machines per floor, suitably wheeled to facilitate sanitizing operations, for a total of eight machines for the entire structure. In this way, the operators on each floor can treat two rooms at a time, in consideration of the fact that the machines are wireless and shall be operated from the corridor through closed doors (so avoiding any operator's exposure to Ozone or UV-C rays). The machines perform cycles, normally requiring from 2 to 20 minutes/each (depending on the function used), so the operator shall just launch cycles, along which he can execute his normal activities. Therefore, the process can be executed part-time by already employed personnel, not requiring any new cost for additional personnel.

Fig. 1: Map of the Structure. Floor 1 of 4 equal floors.

The effectiveness of ozone for sanitization is such that it has interested the scientific community as regards its uses in the current fight against COVID-19, both in hospitals and in transport and offices, as well as in hotels and, in general, in any public or private environment. In an article, [2], ISCO3, the International Scientific Committee on Ozone Therapy, conducted contaminated studies showing that a 30-second exposure to gaseous ozone renders 99% of viruses inactivated. Furthermore, the latter are damaged in the proteins of their envelope and this prevents them from attaching to cells, [3]. In addition, RNA can also break down, destroying the virus. These tests have been carried out on different materials, [4]. Another advantage of gaseous ozone is that it is a natural compound, [2]. In another study, [5], is tested the effectiveness of this element in the sanitization of processing environments for meat products. The goal of the experiments conducted is to evaluate the sanitizing power of gaseous ozone. As the two researchers explain, it is essential to be able to "reach all surfaces and critical points, distributing the sanitizer in a homogenous, constant and safe form". Precisely for this reason the gaseous form is the one that best reaches all areas, even those inaccessible to operators. This feature is also underlined by ISCO3, [2]. The sanitization of surfaces is considered a critical factor for contamination and cross contamination, the disinfection of surfaces can be faced with different methods as treated by more Researchers in different articles, [6], [7], [8], [9], [10], [11], [12], [13], [14], [15], [16], [17], [18]. The disadvantage of ozone, the two researchers note, is its toxicity. For this reason, the rooms sanitized with ozone must be duly confined and then, at the end of the sanitation, destructors and catalysts are needed. By varying the concentration of ozone and keeping the temperature constant at 30°C, the aerobic microbial load was monitored before and after the ozone treatment, thus showing the enormous sanitizing impact of the latter, which proves to be an excellent substitute for chemical sanitizers. In 2020, a study, [19], was drawn up on the use of ozone in the sanitation of dental surgeries. Both, [2], and [19], agree on the particular effectiveness against viruses, increased in case of high relative humidity, about 90%. Depending on the type of organism to be eliminated, both exposure times and concentrations vary. For viruses, such as COVID-19, a concentration of 0.2-4.1 ppm is required for a maximum of 20 minutes. However, these concentrations exceed the limit of toxicity. As explained by, [5], after the treatment it is necessary to reconvert Ozone into Oxygen. Finally, it should be remembered that ozone also eliminates insects, bacteria, molds, spores, and rodents that may be present in the Structure. It is also to be noted the combined use of Ozone with UV-C rays, for effective sanitization of surfaces, [1], [20], [21], [22], [23].

Table 1 details the rooms on each floor reporting the extension of each area and the timing required for full sanitization (Ozone + UV-C).

Table 1. Size and timing of treatment (new equipment)

AREA Vs. TIME OF TREATMENT		AREA	TR-TIME
FLOOR 1 of 4 (equal)		[sqm]	[min]
A	Room	35	20
B	Room	26	15
C	Reception	26	15
I	Living room	26	15
L	Corridor	19	11
M	Dining room	32	19
D	Room	31	18
E	Room	17	10
F	Room	17	10
F2	Bathroom	9	5
G	Room	17	10
G2	Bathroom	8	5
H	Room	15	9
H2	Bathroom	8	5
N	Corridor	108	63
O	Bathrooms	29	17
P	Cabinet	12	7
R	Reception	24	14
S	Bathrooms	28	16
T	Cabinet	10	6
U	Cabinet	12	7
U2	Bathroom	6	4

2 Problem Formulation

The Management of the structure required the Authors to perform a preliminary analysis of the impact that the costs of the new technology would have on the cash flow (economic convenience analysis), compared with the costs that would occur with the assignment to external companies in the two hypotheses of:

- Scenario A (SC. A): 10 treatments/month (minimum indispensable)
- Scenario B (SC. B): 30 treatments/month (recommended hypothesis)

Table 2. Spending per treatment (new equipment)

Cost per treatment (full building)		
Electricity consumption per lamp	14	[Wh]
Llights on per machine (at the same time)	12	[#]
Electricity consumption per machine	168	[Wh]
Electricity consumption per machine	0,168	[kWh]
Cost per kWh	0,2	[€]
Operating time (2 machines)	20,0	[h]
Electricity cost per treatment	0,67	[€]
Machine directly operating time	10,0	[h]
90%, Efficiency saving (along treatment)	-9,0	[h]
4%, Operator extra time (move, setup)	0,4	[h]
Operating time (1 man + 1 machine)	1,4	[h]
Manpower general cost (full cost)	16	[€/h]
Manpower cost per treatment	22,5	[€]
Maintenance cost (8 machines for 6Kh)	4,0	[€]
Total cost per treatment	27	[€]

A benchmark was then conducted by the Authors in consideration of the costs reported by Third Parties. In literature also is treated this topic, [24].

3 Problem Solution

Since the cost of each machine is 4,000€, it can be deduced that the investment cost to serve the entire building is 32,000€ (2 machines per floor per 4 floors). Bearing in mind that the cost of a sanitization treatment for the entire building is 27€, as can be seen in detail from Table 2, the cost for sanitizing the structure, in the two hypotheses considered (10 and 30 treatments/month), would be 270€ and 810€/month respectively. The data necessary for calculations are the following:

- The current cost of an intervention on the entire building (external companies): € 2,064
- Cost of investment (new sanitation equipment, 8 machines): € 32,000
- The life cycle of the sanitation system: is 12 years (against the theoretical 20 years of the estimated duration of the machines), as it is believed that in the next 12 years, more performing technologies will take over from the proposed one, making obsolete the current proposal
- Maintenance costs: maintenance is required to replace lamps and other accessories every 6,000 hours of operation. Therefore, the following calculates the number of interventions to be carried out over the estimated life cycle

Maintenance interventions are calculated separately in the two Scenarios A and B. Recalling that each floor treatment requires 2 machines and 1 Operator, each machine spends 2.5h lamps/treatment (about 300 min per floor divided per 2 machines), so in the case of 10 treatments/month each lamp of each machine operates for 25h/month, that is for 300h/year. It follows that having to be replaced every 6,000h, the replacement frequency is 20 years, so over the 12-year Life Cycle of the machine, there will be no need for the replacement of lamps. Concerning the case of 30 treatments/month, the lighting time of each lamp is 75h/month or 900h/year. Consequently, the theoretical frequency of replacement will be 6,000h/900h per year (6.6 years) and effective as 6 years. Since the cost of replacing lamps and accessories is 1,200€/machine, each intervention on the 8 machines will cost 9,600€, as reported in Table 3.

Table 3. Cost incidence of maintenance (new equipment).

Maintenance costs (lamps and ballasts)		
Guaranteed life of the lamps	6.000,0	[h]
Treatments per day (full building)	1,0	[#]
Machine hours to treat whole building	20,0	[h]
Machines used	8,0	[#]
Direct operating time (machine / day)	2,5	[h]
Days / year	365,0	[h]
Direct operating time (machine / y)	912,9	[h]
First lamp replacement	6,6	[y]
Replacement costs (lamp, ballast)	100,0	[€]
Costs per machine	1.200,0	[€]
Total costs (8 machines)	9.600,0	[€]
Sanitation days (6 y including leap y)	2.400,9	[g]
Daily cosr (lamp consumption, 8 machines)	4,0	[€/g]

The Authors proceeded to study the investment required for the new technology in the 2 Scenarios. The new system proposed is capable of producing significant savings for the adopting structures, with notable benefits compared to the traditional solutions. The economic analysis is developed separately for the 2 different Scenarios A and B. The following tables show the costs attributable to the individual years of the life of the new plant (Table 5 and Table 6), compared to the "Current Spending" illustrated in Table 4, deriving from the use of external companies. The basic data for the construction of these tables are described in the previous paragraphs.

3.1 Current Spending

Table 4. Spending (with External Companies)

Sanitization by Ext. Companies	Treatments/month =>		30
Scenario B (30 sani/month)	Cost / treatment	Area	Spending
YEAR 1	[€/smq]	[sqm]	[€]
Spending (month)	1 €	2064	61.920 €
Spending (year)			743.040 €

Table 5. 10 sanitizations/month (Scenario A)

SCENARIO A			
Sanitization by new 4.0 machines	Treatments/month =>		10
YEAR 1-12	Months	Cost/month	Cost/life cycle
Months 1-12 => 12 months	[#]	[€/month]	[€/life cycle]
Spending (excluding maintenance)	12	240 €	2.880 €

Table 6. 30 sanitizations/month (Scenario B)

SCENARIO B			
Sanitization by new 4.0 machines	Treatments/month =>		30
YEAR 1-12	Months	Cost/month	Cost/life cycle
Months 1-12 => 12 months	[#]	[€/month]	[€/life cycle]
Spending (including maintenance)	12	810 €	9.720 €

Please note that for both the Scenarios analyzed, the cost of decommissioning at the end of the life cycle must be considered.

3.2 Indicators

The analysis was conducted using the classic indicators of the Theory of Investments, specifically the Payback Period (PBP) and the Net Present Value (NPV).

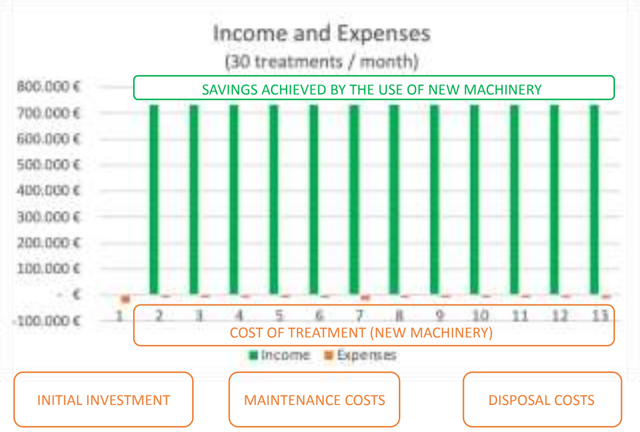

Fig. 2: Cash flow (new equipment)

The PBP can be easily calculated using the income-expenditure graph illustrated in Figure 2 (investment / yearly CF), with an exceptional time frame, lower than one month, so simplifying the assessment of the investment, by releasing the cash in a short time.

The NPV is calculated using the formula:

$$\sum_{t=1}^{n} \frac{F_t}{(1+i)^t} - F_0$$

In this case, the NPV represents the total savings expected using the new technology, updated at time zero. As such, in Table 7 we present the PBP and NPV for 10 treatments/month (SC. A). Similarly, in Table 8 we showcase the PBP and NPV for 30 treatments/month (SC. B).

Table 7. PBP and NPV for 10 treatments/month (SC. A)

SCENARIO A	YEAR 0	YEAR ...	YEAR 12
10 treatments /months	2021	...	2033
Discounting exponent	0,0	...	5,0
Expenses			
Investment	32.000 €		
Maintenance cost			excluded
Disposal cost			5.000 €
Income (annual benefit)			
Expenditure saving		...	733.320 €
Total income	- €	...	739.800 €
Total Expenses	- 32.000 €	...	- 8.240 €
Cash flow (CF)	- 32.000 €	...	731.560 €
Cumulative cash flow	- 32.000 €	...	8.801.720 €
i = discount rate	8,0%	...	
Discounted cash flow	- 32.000 €	...	461.007 €
PbP (Pay Back Period)	0,04	y	
NPV (Net Present Value)	6.908.487	€	

Table 8. PBP and NPV for 30 treatments/month (SC. B)

SCENARIO B	YEAR 0	YEAR ...	YEAR 12
30 treatments /months	2021	...	2033
Discounting exponent	0,0	...	5,0
Expenses			
Investment	32.000 €		
Maintenance cost			9.600 €
Disposal cost			5.000 €
Income (annual benefit)			
Expenditure saving		...	733.320 €
Total income	- €	...	733.320 €
Total Expenses	- 32.000 €	...	- 14.720 €
Cash flow (CF)	- 32.000 €	...	718.600 €
Cumulative cash flow	- 32.000 €	...	8.636.600 €
i = discount rate	8,0%	...	
Discounted cash flow	- 32.000 €	...	452.840 €
PbP (Pay Back Period)	0,04	y	
NPV (Net Present Value)	6.778.690	€	

4 Conclusion

However, in the need to raise the current performance at least from 2 sanitizations to 10/month, with a target value of 30/month, the Management has required the Authors to study (in addition to the technical feasibility) the economic sustainability of the new 4.0 technology, to understand the impact on the Structure's economy. The result of the study conducted is largely favorable for the Structure as the analysis of the investment, carried out both for Scenario A and for Scenario B, demonstrates two significantly positive values for NPV (6.8M€ of discounted savings) and PBP (less than 2 years), along the useful life cycle of the new machinery (assumed prudently in 12 years). According to the Management's mandate, the impact of the investment on the structure's cash flow was then assessed, demonstrating full sustainability with a widely positive cash flow along the whole life cycle. The results induced the Management to adopt the 4.0 technology identified. This decision was a source of sincere satisfaction for the Authors as they are convinced that they have made a positive contribution to the fight against viruses and bacteria that, in a globalized world, will progressively generate more dangerous threats. The test case also highlights the possibility for companies that deal with sanitization to use the proposed methodology to replace chemical products, with a clear impact on economics (significant cost reduction), and benefits for People's safety and the environment. The results of the analysis also highlight the fact that companies that deal with sanitization can use the proposed methodology, to replace the current chemical products, with clear economic benefits for them and environmental benefits for Humanity. Also, in this case, Engineering 4.0 has shown the capability to provide adequate support to healthcare activities. In consideration of this, the Authors decided to direct a significant part of their research to support Medical, Surgical, and Nursing Equips.

References:

[1] Mosca, R., Mosca, M., Revetria, R., Cassettari, L., Currò, F., Galli, G. (2021). "Sanitizing of Confined Spaces Using Gaseous Ozone Produced by 4.0 Machines", WCE2021 Best Paper Award, ICSBB_210312Rx. Conference proceedings published by IAENG, ISBN: 978-988-14049-2-3.

[2] Apuzzo, Dario, and Membro di ISCO. "Uso potenziale dell'ozono nella SARS-CoV-2/COVID-19." Comitato Scientifico Internazionale d'Ozonoterapia ISCO3. ISCO3 / EPI / 00/04 (Madrid, 14 marzo 2020). Approvato da ISCO3 il 13/03/2020.

[3] Menzel DB. Oxidation of biologically active reducing substances by ozone. Arch Environ Health. 1971 Aug;23(2):149-53. DOI: 10.1080/00039896.1971.10665973. PMID: 4397679.

[4] van Doremalen N, Bushmaker T, Morris DH, Holbrook MG, Gamble A, Williamson BN, Tamin A, Harcourt JL, Thornburg NJ, Gerber SI, Lloyd-Smith JO, de Wit E, Munster VJ., Aerosol and Surface Stability of SARS-CoV-2 as Compared with SARS-CoV-1, The New England Journal of Medicine, 2020; 382:1564-1567,
DOI: 10.1056/NEJMc2004973.

[5] Fortini, G., and C. C. Cardoso. Guidelines for the use of gaseous ozone in the sanitization of meat product processing environments ("Linee guida per l'utilizzo dell'ozono gassoso nella sanificazione degli ambienti di lavorazione di prodotti a base di carne"). 2016. SSICA Research Foundation.

[6] A. Scroccarello, F. Della Pelle, M. Del Carlo, D. Compagnone (2022). Monitoring disinfection in the Covid-19 era. A reagent-free nanostructured smartphone-based device for the detection of oxidative disinfectants. Microchemical Journal 175 (2022) 107165. https://doi.org/10.1016/j.microc.2021.107165. 0026-265X/,2021 Elsevier B.V.

[7] M.C. Celina, E. Martinez, M.A. Omana, A. Sanchez, D. Wiemann, M. Tezak, T.R. Dargaville (2020), Extended use of face masks during the COVID-19 pandemic - Thermal conditioning and spray-on surface disinfection, Polymer Degradation and Stability 179 (2020) 109251. https://doi.org/10.1016/j.polymdegradstab.2020.109251. 0141-3910/¬© 2020 Published by Elsevier Ltd.

[8] S. AlZain (2018), Effect of 0.5% glutaraldehyde disinfection on surface wettability of elastomeric impression materials. Saudi Dental Journal (2019) 31, 122-128.
https://doi.org/10.1016/j.sdentj.2018.10.002. 1013-9052¬©2018 The Author. Production and hosting by Elsevier B.V. on behalf of King Saud University.

[9] N. D. Hollis, J.M. Thierry, A.G. Garcia-Williams (2020). Self-reported handwashing and surface disinfection behaviors by U.S. adults with disabilities to prevent COVID-19, Spring 2020. Disability and Health Journal 14 (2021) 101096. https://doi.org/10.1016/j.dhjo.2021.101096. 1936-6574/Published by Elsevier Inc.

[10] W. A. Rutala and D. J.Weber (2001). Surface disinfection: should we do it? Journal of Hospital infection. 48 (Supplement A): S64-S68. DOI: IO. I053/jhin.200 I .0973. 0 200 I The Hospital Infection Society. 0195-670 I/O I /OAOS64.

[11] G. McDonnell a, P. Burke (2011). Disinfection: is it time to reconsider Spaulding? Journal of Hospital Infection 78 (2011) 163e170. 0195-6701/$ e see front matter, 2011 The Healthcare Infection Society. Published by Elsevier Ltd. All rights reserved. DOI: 10.1016/j.jhin.2011.05.002

[12] S. Petti, G.A. Messano (2016). Nano-TiO2-based photocatalytic disinfection of environmental surfaces contaminated by meticillin-resistant Staphylococcus aureus. Journal of Hospital Infection 93 (2016) 78-82. http://dx.doi.org/10.1016/j.jhin.2016.01.020. 0195-6701/a 2016 The Healthcare Infection Society. Published by Elsevier Ltd.

[13] K. Steinhauer, T.L. Meister, D. Todt, A. Krawczyk, L. Pa√üvogel, B. Becker, D. Paulmann, B. Bischoff, M. Eggers, S. Pfaender, F.H.H. Brill, E. Steinmann (2021). Virucidal efficacy of different formulations for hand and surface disinfection targeting SARS CoV-2. Journal of Hospital Infection 112 (2021) 27-30. https://doi.org/10.1016/j.jhin.2021.03.015. 0195-6701/, 2021 The Healthcare Infection Society.

[14] W. A. Rutala and D. J.Weber (2016). Monitoring and improving the effectiveness of surface cleaning and disinfection. http://dx.doi.org/10.1016/j.ajic.2015.10.039.

[15] K. Gallandat, R. C. Kolus, T. R. Julian, D. S. Lantagne (2020). A systematic review of chlorine-based surface disinfection efficacy to inform recommendations for low-resource outbreak settings. American Journal of Infection Control 49 (2021) 90,àí103. https://doi.org/10.1016/j.ajic.2020.05.014. 0196-6553/, 2020 The Author(s). Published by Elsevier Inc. on behalf of Association for Professionals in Infection Control and Epidemiology, Inc.

[16] S. Thakar, R. K. Malhan, P. M. Bhatt, S. K. Gupta (2021). Area-Coverage Planning for Spray-based Surface Disinfection with a Mobile Manipulator. Robotics and Autonomous Systems 147 (2022) 103920. https://doi.org/10.1016/j.robot.2021.103920. 0921-8890/, 2021 Elsevier B.V.

[17] S. J. Volkoff, T. J. Carlson, K. Leik, J. J. Smith, D. Graves, P. Dennis, T. Aris, D. Cuthbertson, A. Holmes, K. Craig, B. Marvin & E. Nesbit (2020). Demonstrated SARS-CoV-2 Surface Disinfection Using Ozone. Ozone: Science & Engineering. The Journal of the International Ozone Association. 43:4, 296-305, DOI: 10.1080/01919512.2020.1863770.

[18] A. M. Wilson, K. A. Reynolds, J. D. Sexton, R. A. Canalesa (2018). Modeling Surface Disinfection Needs To Meet Microbial Risk Reduction Targets. American Society for Microbiology. Public and environmental health microbiology. Applied and environmental microbiology. September 2018 Volume 84 Issue 18 e00709-18. DOI: https://doi.org/10.1128/AEM.00709-18.

[19] G. Molina Roja (2020), Use of ozone for sanitizing environments in the dental practice. Evaluation of effectiveness and health consequences ("Utilizzo dell'ozono per la sanificazione degli ambienti nello studio odontoiatrico. Valutazione dell'efficacia e conseguenze per la salute"). ANDI Associazione Nazionale Dentisti Italiani. 16 Giugno 2020.

[20] Mosca, R., Mosca, M., Revetria, R., Currò, F., Briatore, F., (2022). "Fighting Hospital Infections with Engineering 4.0", Conference Paper, Lecture Notes in Networks and Systems "Advances in System-Integrated Intelligence", 2022, 546 LNNS, pp. 310-317, Springer, Lecture Notes in Networks and Systems, 2023, 546 LNNS, pp. 235-244, ISSN 2367-3370, ISBN: 978-3-031-16280-0, DOI: 10.1007/978-3-031-16281-7.

[21] Mosca, R., Mosca, M., Revetria, R., Currò, F., Briatore, F., (2022). Engineering Solutions 4.0 in the fight against the spread of Covid 19 A new Methodology including processes, procedures and devices. AIDI - Italian Association of Industrial Operations Professors. Proceedings of the Summer School Francesco Turco2022 27th Summer School Francesco Turco, 2022. Code 286459. ISSN: 22838996.

[22] G. Katara, N. Hemvani, S. Chitnis, V. Chitnis, D.S. Chitnis (2008). Surface disinfection by exposure to germicidal UV light. Indian Journal of Medical Microbiology, (2008) 26(3): pp.241-42. DOI: 10.4103/0255-0857.42034

[23] V. Fejes, D. Szucs, K. Sipos, V. S. Poor (2022). Effect of ozone disinfection on forensic STR profiling. Forensic Science International 333 (2022) 111212. https://doi.org/10.1016/j.forsciint.2022.111212. 0379-0738/, 2022 The Author(s). Published by Elsevier B.V.

[24] E. Tchouaket Nguemeleu, S. Robins, S. Boivin, D. Sia, K. Kilpatrick, B. Dubreuil, C. Larouche, N. Parisien and J. Letourneau (2021). A pre-pandemic COVID-19 assessment of the costs of prevention and control interventions for healthcare associated infections in medical and surgical wards in QueÃÅbec. BMC (Part of Springer Nature). Antimicrobial Resistance & Infection Control. (2021) 10:150. https://doi.org/10.1186/s13756-021-01000-y.

Contribution of Individual Authors to the Creation of a Scientific Article (Ghostwriting Policy)

All authors contributed to the study conception and design. Conceptualization, material and images preparation, data collection and analysis were performed by Roberto Mosca and Marco Mosca. The first draft of the manuscript was written by Roberto Mosca and Marco Mosca and all authors commented on previous versions of the manuscript. Engineering solutions were designed by Fabio Currò. Literature review was conducted by Federico Briatore as well as final editing.

Sources of Funding for Research Presented in a Scientific Article or Scientific Article Itself

No funding was received for conducting this study.

Conflict of Interest

The authors have no conflict of interest to declare.